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THE SYDNEY HARBOR BRIDGE, AUSTRALIA.

The Sydney Harbor Bridge Advisory Board has issued its official report upon the designs and tenders submitted in connection with the proposed bridge over Sydney Harbor, which is to connect Sydney with North Sydney. From this report the following material may be obtained:

The history of this project commenced in 1878, when the then Commissioner of Roads and Bridges made an unsuccessful application for authority to make the necessary surveys and borings for a bridge to the North Shore. Between 1880 and 1890 various propositions were made to the Government for the erection of a bridge, and plans were submitted, but nothing was done until March, 1890, when a Royal Commission was appointed to consider "the expediency of connecting the North Shore by means of a bridge not obstructing the harbor navigation." This commission was in existence for a year, and then found that it was then inexpedient to build a bridge or tunnel for this purpose. In 1896-8 the question was again brought up in the shape of bridge and tunnel bills, with no result; but on Jan. 4, 1900, the Government advertised for competitive designs and proposals. The conditions stipulated that the bridge was to be one-span, with a clear headway of 180 ft. above spring-tide for at least the middle 600 ft. of its length. The deck was to include two 10 ft. footways, and two 20 ft. roadways, or one roadway 40 ft. wide. In all 24 schemes were submitted; but the Board of Advisers reported that the best of the designs was unsatisfactory, and they rejected them all, but it awarded a first and second prize of £1,000 and £500.

On Dec. 4, 1900, the Board again reported and suggested that the American Bridge Co. be asked to submit designs for both a cantilever and a suspension bridge, including a roadway of 4½-in. hardwood blocks and a maximum unit stress in the tension of all steels—except cables, of 7½ tons, with deductions for alternating stresses. The Board stated that the reason for this suggestion was—that although it was impossible to award the prize to either of the American designs submitted, they would probably prove the best subjects for negotiations; as, were the suggested modifications carried out, the increased cost of the bridge and approaches would still remain at a much lower figure than the design awarded the first prize. Applications having been received from several others of the competing firms, on Feb. 11, 1901, the Board recommended that six of the bona-fide tenderers be allowed to modify their offers, on certain stipulated conditions. On March 25, 1901, a new advisory board was appointed, which makes the present report:

As the result of hearing evidence from those representing the shipping interests, as to the clear span and headway demanded, on May 17, 1901, the Board invited tenders for a bridge with a main span of not less than 1,200 ft., a total length of 3,000 ft., and a clear headway at high spring-tide of 170 ft. for a length at least 600 ft., diminished to 120 ft. at the limits of the 1,200-ft. fairway. The deck was to include a double line of railway, two wood-blocked roadways, each 30 ft. wide, or one 60 ft. wide, and two footways, each 12 ft. wide. The date of the reception of these tenders was later extended from Feb. 28 to June 30, 1902.

Thirteen designs were received; with bids ranging from £1,794,118 for the Cleveland Bridge & Engineering Co. to £3,050,750 for the Fives-Lille Co., of Paris. Lower bids were received for some of a series of alternative plans submitted by J. Stewart & Co. The Phoenix Bridge Co., of the United States, offered to build a bridge for £1,200,000; but the Board decided that they could not accept the plans, as they did not come up to the requirements. The report discusses the merits of the various plans at length, including three amended tenders submitted on March 16, 1903. This Board, in its final report of Nov. 25, 1903, recommended the adoption of the plan submitted by J. Stewart & Co., the total estimated cost of the bridge and approaches being £1,940,050; the time of completion of the main bridge was to be 5½ years. The members of the Board signing this report were—J. Davis, M. Inst. C. E., Chairman; H. Deane, M. Inst. C. E., Engineer in Chief for Railways; W. L. Vernon, F. R. I. B. A., Government Architect; E. M. de Burgh, M. Inst. C. E., Engineer for Bridges; W. H. Warren, M. Inst. C. E., Wh. Sc., Challis Professor of Engineering, and John M. Purves, M. A.

One of the most important matters affecting the design and cost of the bridge is the foundation for the north main pier. The dead weight of the superstruction and the live load thereon would amount to 20,000 to 30,000 tons, and to this must be added the very considerable weight of the pier itself. At the site of this pier the depth to the rock is about 170 ft., with the rock overlaid by 128 ft. of clay and sand, 7 ft. of silt and 37 ft. of water. The Board, after making experiments with a cylinder filled with concrete, concluded that it would be necessary to found this pier upon the rock. The firm of J. Stewart & Co., in their tender, propose to either sink a caisson by dredging in open wells; or they will employ the freezing process for penetrating the clay.

The report does not fully describe the plan accepted, and here illustrated, but from the text

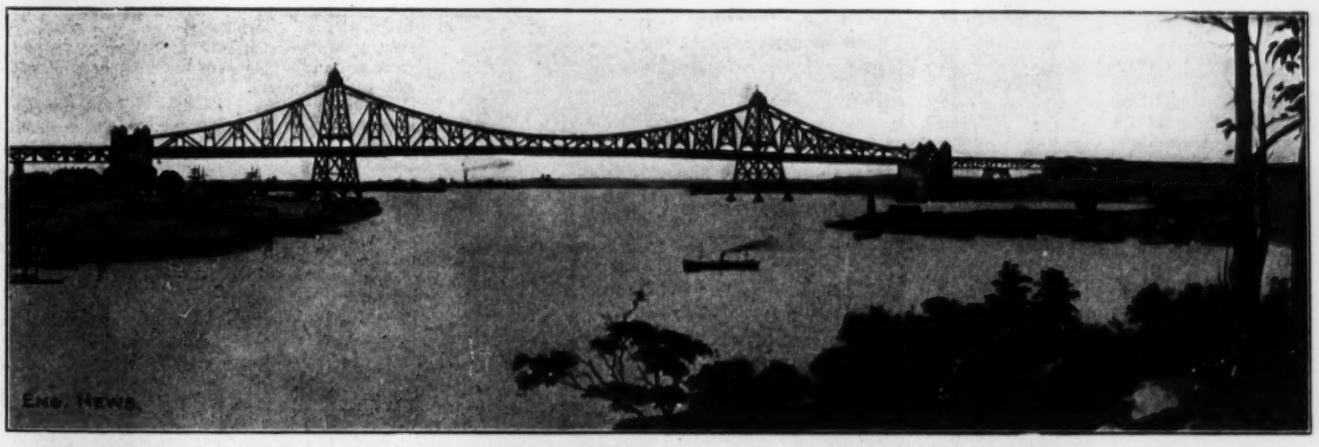


FIG. 1. PERSPECTIVE VIEW OF ACCEPTED DESIGN FOR CANTILEVER BRIDGE OVER SYDNEY HARBOR, AUSTRALIA. LENGTH OF MAIN SPAN, 1,350 FT.

Submitted by J. Stewart & Co., Sydney. Designed by the Vereinigte Maschinenfabrik Augsburg and Maschinenbaugesellschaft Nurnberg, Germany.

the following general description can be given. The design provides for a cantilever bridge with a main span of 1,350 ft. between centers of piers. The northern shore-arm of the cantilever is 580 ft. long, and the southern shore-arm is reduced to 500 ft. to meet approach conditions. The approach spans are each 270 ft. The deck-system

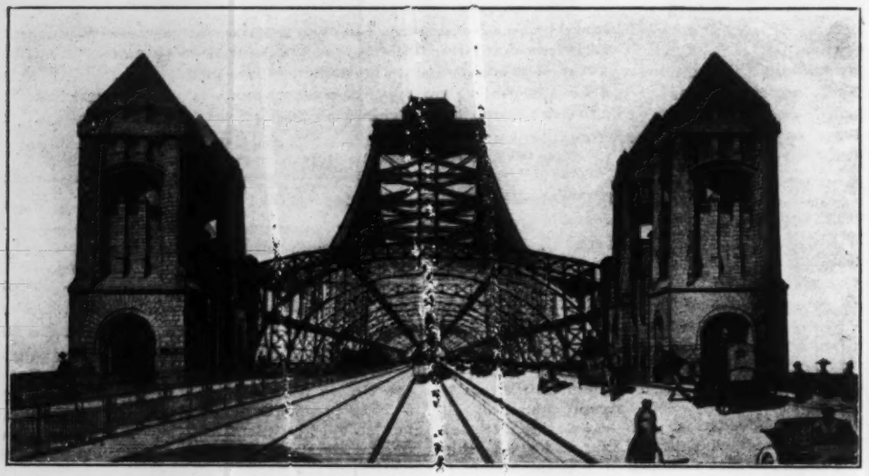


FIG. 2. PORTALS OF SYDNEY HARBOR BRIDGE.

includes a wood-block roadway, 35 ft. wide on the eastern side of the bridge, a double line of tramway upon an open deck alongside of it, and on the west side a double line of railway, also on an open deck. Outside the cantilevers and on either side of the bridge is a footway 10 ft. wide. The tops of the main towers are 400 ft. above high water level, including a pavilion on one of them provided with an elevator, for the accommodation of sightseers. No less than ten separate plans were submitted for the foundation of the northern pier; including a pneumatic foundation on the clay, 90 ft. deep; two schemes for a pile foundation of wood or steel; a combined caisson dredging and partial freezing process for the lower portion, and a complete freezing scheme, in which it is proposed to form an island extending above high water and then to freeze the material overlying the rocks. A dry shaft would then be excavated in the center and the pier built up from the rock.

It should have been stated in its proper place, that the E. & C. Bridge Co., which submitted four plans and bids at the original letting of June, 1902, ranging from £1,792,962 to £1,866,395, was the London representative of the Bridge and Construction Department of the Pennsylvania Steel Co., of Steelton, Pa. The design provided for a suspension bridge with a main span of 1,300 ft.; and on the north side, one span of 320 ft. and one span of 210 ft., and 583 ft. of steel trestles in 30 to 60 ft. spans. On the south side there were two spans of 230 ft. each. The top of the towers was 351 ft. above high-water mark. These towers carried four cables and two three-hinged stiffening trusses. Several modifications of this plan were submitted, chiefly in the matter of the north pier foundation. These foundation plans included a caisson sunk 105 ft. by the pneumatic method, and a similar foundation 90 ft. deep; and a foundation carried 155 ft. deep by open dredging in a steel caisson.

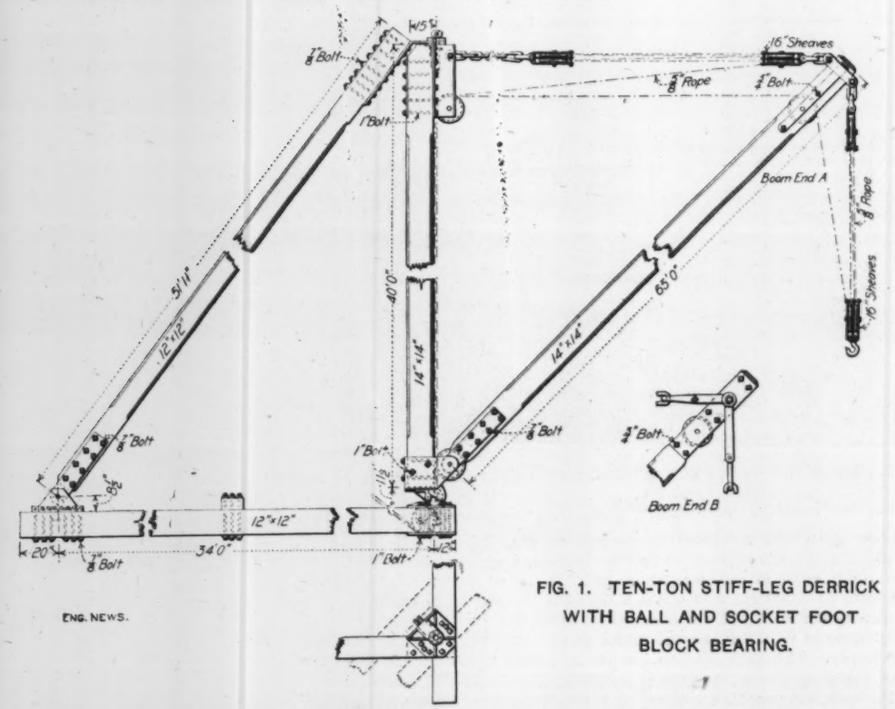


FIG. 1. TEN-TON STIFF-LEG DERRICK WITH BALL AND SOCKET FOOT BLOCK BEARING.

One of the most interesting features of the scheme is the proposed freezing of the ground for the foundation of the north pier. This seems to be determined upon; though Mr. Alfred Noble, Past President of the American Society of Civil Engineers, gave the following interesting opinion upon this foundation in connection with the plans submitted by the Pennsylvania Steel Co.:—The material is reported to be stiff, blue clay. For the plan forwarded, the gross weight on the foundation is about 6.3 tons per square foot. The foundation is 57 ft. below the mud surface, or 1 ft. below the water line. At this depth, says Mr. Noble, material will safely bear a greater load than if imposed near the surface; and, "if the clay is a firm, hard clay, I think that the load of 6.3 tons per square foot is moderate." Mr. Noble goes on to say that in considering such cases it is customary to deduct the weight of the material which the pier has displaced, whether water or earth. If this course is here followed, the net load on this foundation is about 2½ tons per square foot. This method is only approximate, but experience shows that it is safe. It is suggested that if the material is found to be less firm than is desirable, the base could be enlarged, as was proposed by Mr. Thomson, the engineer.

The Board in its several meetings went quite fully into the cost and possibilities of the freezing process, though much of the evidence produced was from American sources and is already familiar to our readers. In general, it was believed that an ice-ring 5 ft. thick on the average and 7 ft. at the bottom would be sufficient, the freezing penetrating 3 or 4 ft. into the rock. To prevent any bad affect of the cold upon the concrete, a double wooden shaft lining enclosing 9 ins. of sawdust might be used. The pipes proposed are 8 ins. diameter, enclosing a 2½-in. circulating pipe. The proposition includes the freezing solid of about 6,000 tons of earth. A rough estimate of the cost of the freezing plant was £30,000, not including the piping system, which might cost £10,000 more; including contingencies, the estimate was finally made £50,000 for the whole work connected with freezing.

A DERRICK WITH BALL AND SOCKET FOOT-BLOCK BEARING.

The accompanying illustrations show a new form of derrick that has recently been put on the market by The Terry & Tench Co., of New York City. In general appearance this new derrick resembles the ordinary form of stiff-leg and guy derricks, but its details, and particularly those of the mast-head irons, mast step and foot block, are of novel design, and are intended to secure greater strength and ease of operation than are obtainable with the customary construction of these parts.

The general appearance of the new derrick is shown by the drawings of Fig. 1. These illustrate a 10-ton stiff-leg derrick, but exactly the same irons are employed for guy derricks, except, of course, that a guy rope spider is added to the mast-head irons, and that the leg irons are done away with. Referring to the illustrations, it will be seen that two forms of boom-end irons are employed. The form preferred by the builders is that shown at A, since it enables the load to be lifted higher for the same elevation of boom than does the bail arrangement shown at B. Another new feature is the use of a chain instead of a single link for supporting the topping lift.

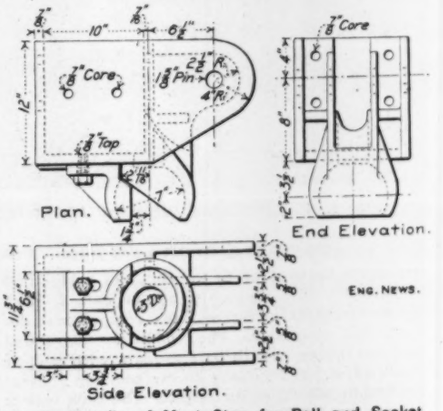


Fig. 2. Details of Mast Step for Ball and Socket Bearing.

This chain enables the boom to be swung around closer against the stiff-leg than does the single link.

Returning now to the mast-irons, it will be seen that they consist of a front and back plate butted together through the mast. The front plate has riveted to it two angles, which carry the gudgeon pin for topping lift connection and head sheave. The

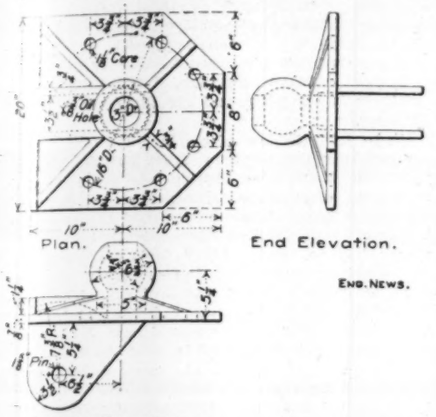


Fig. 3. Details of Foot Block for Ball and Socket Bearing.

timber is not cut into or reduced in section by these irons in any way, except by the butts connecting the front and back plates. The mast step and foot block irons are of more particular interest. The foot block, as will be seen, consists of a base plate carrying a ball pivot. The mast step casting consists of two parts, the step proper, with its recess for the mast bottom, and a sort of hemispherical socket to set over the ball pivot of the foot block, and the lock casting, which clasps around the ball pivot and prevents the mast from being jolted off its bearing. Together the mast-step and foot-block constitute a ball and socket joint in place of the usual pin and plate bearing. This prevents binding and excessive friction when the mast gets out of plumb, particularly in guy derricks. The leg irons and other details are clearly shown by Fig. 1 and Figs. 2 and 3 show the mast step and foot block details that have been described.

500-FT. STEEL ARCH BRIDGE OVER THE ZAMBESI RIVER, SOUTH AFRICA.

The Rhodesian Railway, promoted by the late Mr. Cecil Rhodes to extend from the South African railway system into the heart of Central Africa, and to form a link in the trans-continental "Cape to Cairo" railway, has now reached the great Zambesi River, 1643 miles from Cape Town. This river is to be crossed by a steel arch bridge just below the Victoria Falls. The width of the river above and at the falls is about a mile, but the falls are formed by a great rent or fissure 250 to 400 ft. wide and 400 ft. deep, which extends entirely across the river bed. Through the downstream face of this pit opens a narrow gorge, which extends in a zigzag course for a length of some 40 miles; beyond this the channel again widens. The bridge will have a main span of 500 ft., composed of steel arch trusses resembling the two Niagara river bridges. There will also be two parallel-chord deck truss spans of 87½ ft. and 62½ ft., extending from the ends of the main span to the abutments. The bridge will be 30 ft. wide, sufficient for a double track. The rail level will be 420 ft. above low-water level, or 380 ft. above high water, making this the highest bridge in the world. The accompanying view (from a wash drawing on a photograph) shows the general character of the design. Drawings and photographs of this bridge and its surroundings form a striking exhibit in the Transportation Building at the St. Louis Exhibition. The Chief Engineer is Sir Douglas Fox, M. Am. Soc. C. E., M. Inst. C. E., of London, England. The contract is held by the Cleveland Bridge & Engineering Co., of Darlington, England.

The foundations of the bridge are already finished. In the construction of the bridge itself no falsework is possible. It has therefore been found necessary to build from each end simultaneously as a cantilever until the work meets in the middle. The material is conveyed across the gorge by a Brothers' electric balanced cableway of 870 ft. span, which was illustrated in our issue of May 12 last.

The electric cableway is also being used for carrying over material for the extension of the line 100 miles north from the Victoria Falls to Kalomo, the capital of northwestern Rhodesia. This extension will do a great deal to facilitate the transport difficulties which at present hinder the development of the great northern copper fields.

Already plans have been made to develop the water power of the falls. It is estimated that when the river is in flood the volume of water is about double that at Niagara, and represents about 35,000,000 HP. The electrical power would be delivered to long-distance transmission lines, and distributed to the copper, gold and coal fields which are already being opened up.

For much of the above information we are indebted to Mr. D. E. Brodie, Assistant Secretary of the British South Africa Co., London, England.

INCRUSTATIONS, DEPOSITS AND ORGANIC GROWTHS IN PIPES AND OTHER WATER CONDUITS.

A paper entitled "Deposits in Pipes and Other Channels Conveying Potable Water," presented before the Institution of Civil Engineers by Prof. James C. Brown, has just been printed in pamphlet form.*

INCRUSTATIONS ON UNPROTECTED IRON PIPES.

Instead of calling the units of incrustation nodules, as is commonly done in America, Professor Brown calls them limpets. He thus describes a section through one of the limpets:

The central portion is black when fresh, and soft. It often contains a little sulphide of iron as well as oxide; it becomes red on exposure to air; the middle layers are often orange-red ferric oxide, and sometimes contain iron-organisms of the well-known rosary form which a high magnification resolves into a double ribbon-shaped spiral twisted closely upon itself. The limpet-shaped cones vary in consistence; when well developed they are hard outside and softer within. The outer concentric layers are denser, sometimes quite hard; they are composed of ferric oxide, but include hard black layers of magnetic oxide of iron, in which dead organisms can occasionally be found. The interior is softer; generally black when fresh, but becoming red on exposure. Sometimes there are orange layers between the black interior and the hard outer crust.

STEEL ARCH BRIDGE OVER THE ZAMBESI RIVER AT THE VICTORIA FALLS; RHODESIAN RAILWAYS, SOUTH AFRICA.
Sir Douglas Fox, M. Am. Soc. C. E., M. Inst. C. E., London, England, Chief Engineer.
Cleveland Bridge & Engineering Co., Darlington, England, Contractors.

After disposing of the idea held by some that the incrustations are produced or started by iron organisms, the author remarks that no chemical treatment of the water flowing through pipes will prevent the corrosion, and recommends and describes the preservative coating pitch brought to public notice years ago by Dr. Angus Smith. It appears, however, that "the material and the process which go by his name in commerce are not wholly satisfactory" in Great Britain, just as they are not in the United States.

DEPOSITS AND GROWTHS DEPENDING ON THE COMPOSITION OF THE WATER.

Calcium carbonate, "formed by the escape of carbonic acid from water containing bicarbonate of lime," is first mentioned. The best preventative of coatings from this substance is said to be Clark's process of water-softening, by means of milk of lime and sedimentation.

Black slime is another troublesome deposit. It contains a great deal of iron, but since the deposit forms on brick, stone and wood conduits, the iron must come from the water itself, and not from iron pipes. The author had never been able to find a particle of peat in slime-forming water. Analyses of samples from various sources show that

the dried slime contains a small quantity of vegetable carbon compounds, but no trace of peat; and that it consists mainly of organic matter containing much ferric hydrate together with manganic and manganous oxides, giving a black color to the whole; while entangled in the mass are minute particles of rock, diatoms, and remains of various organisms, with a small quantity of precipitated iron oxides.

An experiment was made by the author which showed that the slime forms in the absence of peat and also the process of formation. Water from a rock tunnel, which had not come in contact with ironwork, was passed through a fine sieve in order to remove particles of peat or other solid matter, including organisms. The water was then passed for five months through pipes well protected with pitch. At the end of the period a coating "of black slime was formed all round the interior of the pipes." On analysis this slime showed the following composition: Ferric oxide, 39.39%; ferrous oxide, trace; manganous oxide, 17.38; manganic peroxide, 1.30; lime, 1.57; magnesia, 1.64; loss on ignition, combined water, animal and vegetable matter, 33.63; undetermined 15.09; total, 100%. Of the total solids, 43.89% was of the nature of "sand and insoluble matter."

Using a microscope, the formation of the slimy coating from which the sample just described was taken was found to be as follows:

First there appears a living and growing jelly adhering to the surface of the pipe; dots, and, some months later, spirilla-shaped organisms, appear in this jelly. Iron begins to be deposited not on but in the jelly; and ultimately there are long threads in the jelly, which acquire a sheath. The sheath thickens by deposition of iron oxide, and the living thread elongates more and more, the sheath following up the thread. A tangled mass results; the older portions become more tangled and dense; and all the time particles are mechanically entangled. Finally

*Excerpt Minutes Proc. Inst. C. E., Vol. CLVI., Part II. (1903-4).

the organism dies at the older end and breaks down, losing its form, and becoming a gelatinous, flocculent mass of dark ochreous deposit, with the younger sheaths and living threads growing out of it. Treated with oxalic acid at this stage, the metals are dissolved, and disclose faintly the broken down and shapeless carbon compound of the disintegrated threads, some of the sheaths occasionally remaining visible.

After reviewing various theories and experiments relating to these organisms and accepting

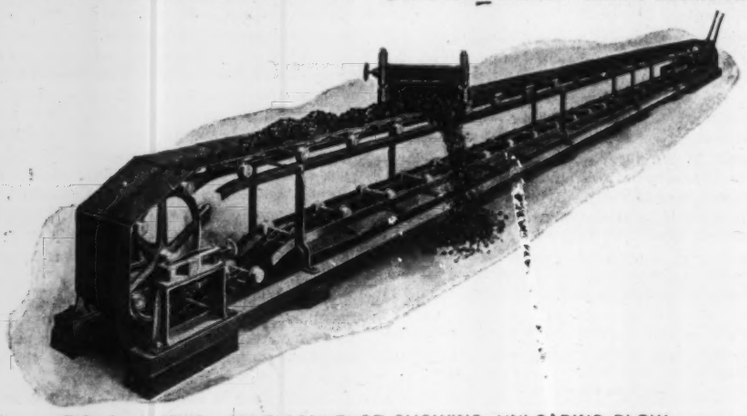


FIG. 1. A STEEL BELT CONVEYOR SHOWING UNLOADING PLOW.

the account and classification given by Migula,* of Carlsruhe, in 1898-1900, Professor Brown continues:

> The germs and young forms of Chlamydothrix come down with the water, and can be found in it by filtration or centrifugal separation. They attach themselves to, and grow on, the inner surface of the pipes and channels. It is known to botanists that these organisms grow attached to something, rather than freely floating in water. First, there is a jelly with specks in it. These specks enlarge and become spiral, then long and twisted, and then become threads having a gelatinous sheath. Iron oxide is deposited in the gelatinous sheaths, which continue to thicken. The older part becomes choked and intertwined, dries, and disintegrates; while the thread-like organism pushes out at the free end, and the thickening sheath follows it up. While these tangled filaments are growing, the solid particles in the water and broken-off floating organisms are caught and retained by the gelatinous threads. There may possibly be some chemical separation of the oxide of iron; if so, this becomes entangled also; but the oxide of iron comes chiefly from the well-known deposition in the jelly of the organisms; and in the waters which the author has studied the iron is not set free from solution, except by the destruction of the carbon compounds which hold it in solution. The consumption of the carbon compounds is caused by the organisms living upon them. The oxide and dioxide of manganese, which occur in black patches and particles in the slime, have a different origin. Water containing traces of manganese salts forms by oxidation small concretions of dioxide or mixed oxides. This has been proved by examination of natural waters,† and by experiment in the laboratory. Particles of oxides of manganese thus chemically deposited are entangled also, and blacken the slime. If they and other solid particles were not entangled in the slime, they would be found at the bottom of the culvert, and not equally at the top and sides.

As to the cause of the formation of ferruginous slime, the author states that acidity other than that due to carbonic acid is always noted in water that produces it. An invariable accompaniment of the slime is "an appreciable quantity of iron in solution, in combination with organic matter of

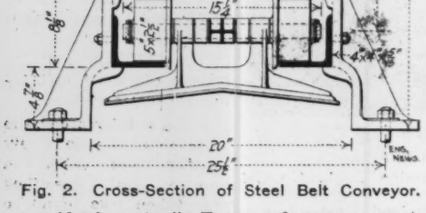


Fig. 2. Cross-Section of Steel Belt Conveyor.

an acid character." Traces of manganese are often present, but not essential.

To check this slimy growth either the organism itself may be attacked or else its food supply may be removed. Complete neutralization of the water by a modification of the Clark water-softening process prevented the growth of the iron-organism when tried experimentally. Straining through the finest gauze delays but does not prevent the growth. Filtration, in a number of instances known to the author has prevented the appearance of the growth of slime beyond the filter bed, although it does not diminish the growth of incrustations. Efficient filtration removes the organic matter, and so removes much of the iron held in combination with the organic acid; and the author has never seen slime grow to any extent in water after good filtration. But there is evidence of a growth of organic jelly, containing oxide of iron, forming a thin film in pipes beyond efficient filter-beds; and it is conceivable that this may, after the lapse of sufficient time, grow in the same manner as before filtration, though at a slower rate.

Finally, Professor Brown recommends the prevention of the slime rather than its removal by a brush. Where brushes are used he advises that they be soft enough so as not "to detach or break the incrustations, if any, beneath the slime." Such breaking, it appears from the context, he fears would give rise to serious corrosion.

*Migula, "System der Bacterien," Vol. I.

†H. S. Pattinson, Trans. Newcastle Chemical Society, Vol. IV., 1879.

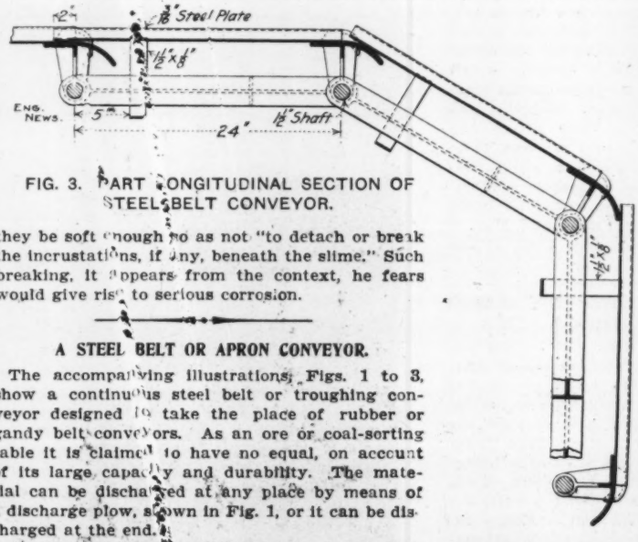


FIG. 3. PART LONGITUDINAL SECTION OF STEEL BELT CONVEYOR.

A STEEL BELT OR APRON CONVEYOR.

The accompanying illustrations, Figs. 1 to 3, show a continuous steel belt or troughing conveyor designed to take the place of rubber or gandy belt conveyors. As an ore or coal-sorting table it is claimed to have no equal, on account of its large capacity and durability. The material can be discharged at any place by means of a discharge plow, shown in Fig. 1, or it can be discharged at the end.

As shown in Figs. 2 and 3, there is a steel chain on each link of which is fastened a saddle for supporting the steel belt, which is made in sections 24 ins. long, and wide enough to give the desired capacity. One end of each steel pan is securely fastened to the saddle, but the other end is free to move forward and back, allowing the steel belt to pass around the sprockets at the end, as shown in Fig. 3. The chain is in one strand, having a 24-in. pitch, fastened together with steel pins, on the ends of which are self-oiling wheels or rollers, Fig. 2, running on a steel track. The chain is designed for a working stress of 10,000 lbs., and travels at a speed of 20 to 60 ft. per min. Due to the use of self-oiling wheels on a rigid track, comparatively little power is required to drive the conveyor at the low speeds commonly used. Long life, as compared with rubber, is claimed for the steel belt, and, consequently, small cost of maintenance. It can also be used for the conveying of hot materials, for which ordinary conveying belts could not be used. This conveyor is manufactured by The C. O. Bartlett & Snow Co., Cleveland, O.

RESULTS OF EXPERIENCE WITH THE BRITISH EMPLOYERS' LIABILITY LAW.

No state in the Union has enacted so radical a measure with respect to the liability of employers for accidents to those engaged in their service as that which has been in force in Great Britain for the past seven years.

In this country the liability of an employer for damages to an injured employee turns on the question whether that employer was negligent in the provision of safe tools, apparatus, etc. If the employee is injured through his own carelessness or that of a fellow workman, it is held that the employer is blameless and should not be held liable for damages.

Up to 1897 the law of employers' liability was substantially the same in Great Britain, but in that year a sweeping change was made by the enactment of a statute founded on an entirely different theory. The old idea, and the one still in force in the United States, is that the employer has no responsibility for an accident to an employee unless he, the employer, was in some way the cause of the accident. The new theory on which the present British statute is based is that the business should bear the burden of supporting those injured in carrying it on.

No amount of care on the part of both employer and workmen can wholly eliminate danger in modern industries. Accidents are bound to occur, and it is held that the cost of caring for the injured should be made a part of the legitimate cost of carrying on the business. In addition, the hope of those who enacted the law was that the vast amount of litigation in damage suits might be reduced.

We shall not take space to state the law in detail as enacted in 1897 and amended in 1900, but among its noteworthy features are the fixing of a compensation for accidents, exceedingly small in comparison with American ideas, the idea being not to penalize the employer, who is often in no way responsible for the accident, but to insure that an injured workman shall have enough support provided to prevent him or those dependent on him from becoming a public charge.

It was, of course, the intention that employers unable to carry the risks themselves should seek protection through insurance, and that has been done.

The act was strongly opposed by employers, and has been severely criticised, so much so that a committee was created some time ago to investigate and report on how the act had actually operated. In "Engineering" of Aug. 12 is given a report of the conclusions reached by this committee. Inasmuch as the matter of employers' liability laws is certain to come up in the United States sooner or later, we have deemed it worth while to reprint this report from our contemporary, as follows:

> The committee—which consisted of Sir Kenelm Digby, K.C.B., Sir Benjamin Brown, D.C.L., M. Inst. C. E., Hi-Honor Judge Lumley Smith, K.C., Captain A. J. G. Chalmers (of the Board of Trade), and Mr. George N. Barnes (Secretary of the Amalgamated Society of Engineers)—were asked to inquire as to (a) what amendments in the law relating to compensation for injuries to workmen are necessary or desirable; and (b) to what classes of employments, not now included in the Workmen's Compensation Acts, those acts can properly be extended, with or without modification. In the course of the inquiry no less than 76 witnesses, including legal experts, and the employers and employed in the chief industries of the country, were examined. The committee also received many written communications from employers' associations and trade unions in response to a circular letter which had been issued inviting them to give the results of their experience. Insurance companies also favored the committee with the results of their experience. In

concerning the working of the acts of 1897 and 1900, the committee directed their attention to the following questions:

(A) Have these acts in their operation been unduly productive of litigation? If so, to what causes can this result be attributed, and how far can this evil be mitigated? With regard to this question the committee have come to the conclusion that the amount of actual litigation produced by the Workmen's Compensation Acts of 1897 and 1900 has been very small when compared with the great number of cases settled by agreement without any reference whatever to legal aid, or to proceedings in court. On the other hand, they think that that proportion may, and ought to be, still further reduced by amendment of some of those provisions of the acts which have been found to be most productive of actual or threatened litigation, and by the provision of more effective machinery for expeditious and inexpensive settlement of doubtful questions of fact, especially by amendments tending to increase the importance of the functions of medical referees.

(B) Have they conduced to prevent the occurrence of accidents in the industries to which they have been applied?

As to this question the committee state that no doubt there has been, at all events in the more highly-organized industries, in the last ten years, a great improvement in the conditions making for safety. How far this is due to new legislation or statutory regulations affecting mines, factories and railways, to a higher standard of carefulness, both on the part of the employers and employed, or to the working of the Compensation Act, the committee found it difficult to say.

(C) How have they affected accident or benefit funds?

The committee are of opinion that the evidence showed that the operation of the act has been largely to put an end to those societies for accident compensation which previously were supported by the joint contributions of employers and workmen.

(D) Have they imposed, or are they likely to impose, any undue burden on the employer?

The committee regarded this as a question of the utmost importance and difficulty. As a result of the evidence which was directed to the solution of this question, the committee are of opinion that in the first instance the burden of compensation must fall on the employer. The ultimate loss consequent thereon will fall with equal or greater weight upon the workman, either by diminution of wages, or loss of employment, or loss through the insolvency of the employer. "The problem therefore," say the committee at page 25 of the Blue Book, "is to attempt such an adjustment of the burden as will enable the great industries of the country to be carried on without an excessive share of the losses occasioned by industrial accidents being thrown on the employer or the employed."

The following table, which shows the ratio of insurance charged by the Employers' Liability Assurance Corporation, Limited, as a result of 4½ years' experience of Workmen's Compensation Acts, is of considerable interest:

	Classification.	Rate per cent. of wages. s.	d.
1.	Trades and manufactories (light)	4	0
2.	Farms and estates	6	0
3.	Trades (heavy)	7	6
4.	Manufactories ((heavy)	11	0
5.	Contractors (land)	12	6
	Builders	20	0
	Builders (small)	15	0
	Contractors, excluding erection, tunneling and blasting	24	0
	Contractors, including erection, tunneling and blasting	50	0
6.	Quarries	24	0
7.	Iron trades (heavy)	25	0
	Engineers	10s. to 20s.	
	Smelting	20	0
8.	Mines	33	0
9.	Contractors (waterside)	47	6
	Stevedores by locality	70s. to 200s.	
	Average	19s.	7d.

(E) Has their operation, on the whole, been beneficial to the workman?

The general answer to this question is decidedly in the affirmative. The complaints brought before the committee on the part of the workman have not generally been directed against the sufficiency of the compensation provided, but have reference chiefly to certain suggested anomalies which create a sense of hardship and injustice.

Consideration of this question suggested two subsidiary questions to the committee, namely: (1) Is adequate provision made by the act against loss through the insolvency of the employer? (2) What has been the effect of the act upon the employment of old, weak or maimed workers?

With regard to the first of these the committee are of opinion that the danger of insolvency, with the consequent distress which would be occasioned, is very real, and should be borne in mind throughout the recommendations to be made both as to the amendment and extension of the act. That there must always be a serious risk of the insolvency of the employer seems to the committee to be the inevitable consequence of the principle of personal liability instead of that of compulsory insurance under proper regulations. As to the second question, it appears to the committee that the operation of the act, as it stands, both as regards the old and infirm, and those who have been maimed, has proved a serious drawback to the advantages which it has in other respects conferred on the workman. They think that some amendment of the act should be made to remove or lessen the difficulty of employing such persons without casting on the employer a liability of such weight as to make it difficult for him to employ this class of labor at all. It is suggested that it should be open to the employer, upon a certificate from the medical referee as to the enfeebled condition of the workman, to employ an infirm or injured person upon special terms as to compensation in case of death or injury from accident. The act should provide a minimum of compensation, but the parties should be free to make their own terms for a larger amount. In the case of old persons, 5s. per week for injury and £25 in case of death, leaving dependents, is suggested. Persons over 60 years of age might be employed on these terms without certificates.

(F) Under what conditions have the acts operated most beneficially?

The evidence has left upon the minds of members of the committee the impression that it is where the organization of the associations, both of employers and workmen, is most complete that there is the least amount of litigation, and the greatest satisfaction with the settlements reached. They further think (1) that the act works most unsatisfactorily, and is most ineffective where labor is unorganized and the workman is obliged to resort to legal assistance; (2) that this tendency is aggravated when the workman is in the employment of a small employer without adequate capital or position to dispose him to be careful as to protecting himself by insurance; and (3) that the system is least appropriate in the case of a casual laborer who has no fixed or settled occupation, but merely picks up jobs where he can.

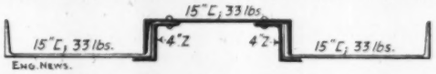


Fig. 2. Section of Steel Core for Proposed Earth Dam at Ellsworth, Me.

A PROPOSED EARTH DAM WITH A STEEL CORE AND A REINFORCED CONCRETE SPILLWAY AT ELLSWORTH, ME.

By J. A. Leonard.*

In connection with the design of a dam and power house at Ellsworth, Me., for the Bar Harbor & Union River Power Co., the writer was called upon to prepare plans for a storage dam at a point on the Union River about four miles above Ellsworth. At the site selected the Union River is about 200 ft. wide and 15 ft. deep; underlying the water is from 12 to 15 ft. of hard clay, overlying the rock. As only a limited amount of money was available for the construction of a storage dam, it was desirable if possible to avoid the large expense of excavating this clay and building a masonry dam on the bed-rock, en-

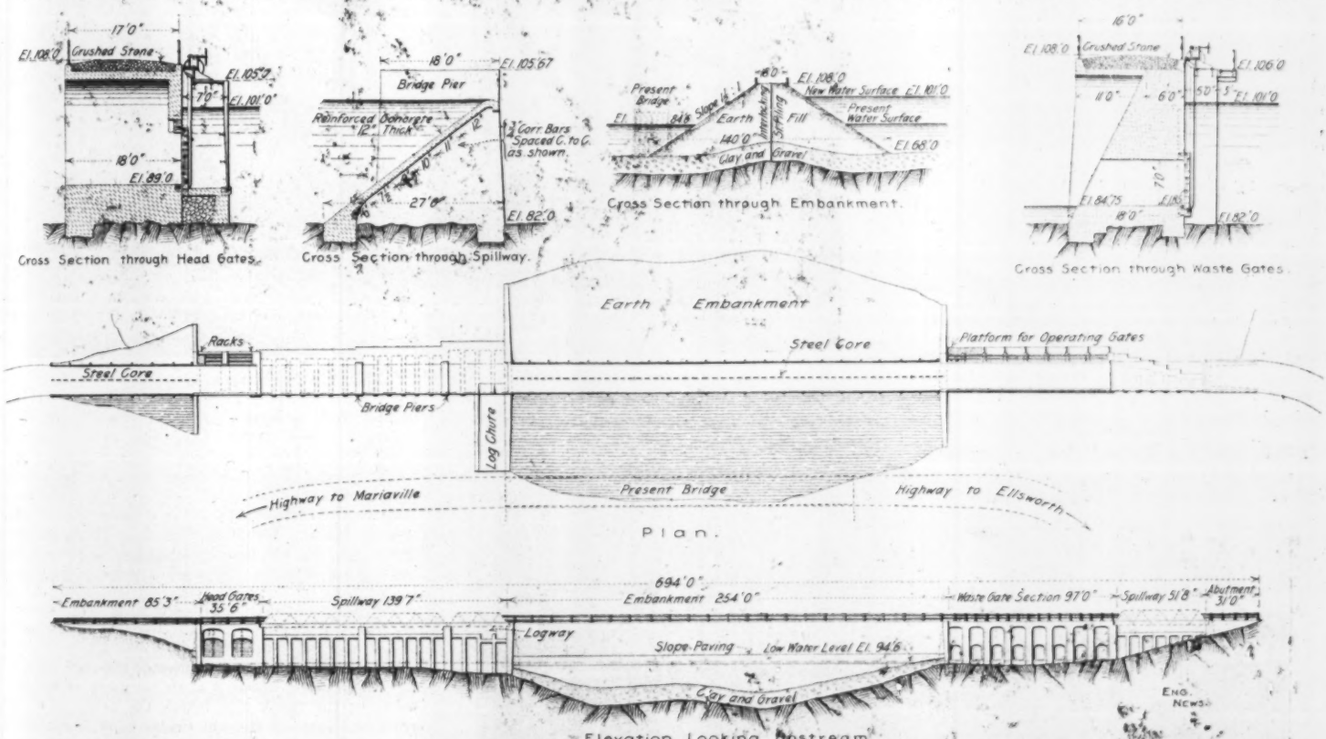


FIG. 1. PLAN AND DETAILS OF A PROPOSED EARTH DAM WITH A STEEL CORE AND A REINFORCED CONCRETE SPILLWAY AT ELLSWORTH, ME.

*Chief Engineer Bar Harbor & Union River Power Co., 467 West 23d St., New York City.

tailing as it did cofferdams about 40 ft. high. The plan designed by the writer contemplates, for this section of the dam, an earth embankment with steel core or diaphragm. It is proposed to construct the steel core by driving Friestedt interlocking channel bar steel piling through the clay down to the bed-rock, and then filling in on each side of the core with earth, the slopes to be riprapped or paved with stone near the water level. The piling will be thoroughly coated with asphaltum or graphite paint. This plan dispenses with the excavation of any of the clay and does away with the cost of a large cofferdam on this section of the work.

The site of the dam is at present occupied by a highway bridge; this bridge will be removed and the highway carried over the top of the new dam as shown by Fig. 1. At the westerly end of the embankment a spillway will be constructed of reinforced concrete on the plan first used by Messrs. Ambursen & Sayles at Theresa, N. Y., and described in Engineering News for Nov. 5, 1903. West of this spillway four head-gates will be built into the dam to supply water for a proposed saw mill below the dam site. East of the embankment will be constructed a concrete abutment containing ten waste gates, to be used for the purpose of drawing the water from the storage reservoir for use at the power plant below, during periods of low water. The reservoir created by this dam will be about fourteen miles long, three miles wide at the widest part and will cover about thirteen square miles in area; when filled even with the crest of the dam the reservoir will contain 3,100,000,000 cu. ft. of water, which can be drawn upon for power purposes.

As this use of channel bar piling (see Fig. 2) is, so far as the writer knows, absolutely new, he would be glad to have the opinion of the readers of Engineering News as to the probable length of life of the channel bars embedded in an earth embankment.

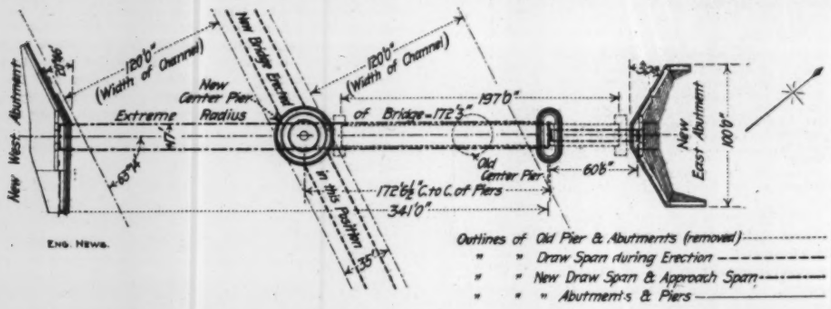

New West Abutment
120'0" (Width of Channel)
New Center Pier. Extreme Radius
New Bridge Pier
120'0" (Width of Channel)
197'0" of Bridge = 172'3"
Old Center Pier
60'0"
New East Abutment
100'0"
172'6½" C. to C. of Piers
341'0"
Eng. News.
Outlines of Old Pier & Abutments (removed)
" " Draw Span during Erection
" " New Draw Span & Approach Span
" " " Abutments & Piers

FIG. 1. LOCATION PLAN OF OLD AND NEW WORK, BLACK RIVER CROSSING OF THE N. Y. C. & ST. L. RY., LORAIN, O.

BRIDGE RENEWAL UNDER UNUSUAL CONDITIONS.

The renewal of a drawbridge on the New York, Chicago & St. Louis Ry., completed recently, was complicated by unusual conditions of location. The drawings and photographic views reproduced herewith show the difficulties of the work and how they were overcome.

The railway line crosses the navigable Black River at Lorain by a swing drawbridge. The old draw, a pin-connected truss deck bridge, was 197 ft. in span, but the widening of the river channel now being done, from Lake Erie to the new plant of the United States Steel Corporation, made a longer draw necessary. The new draw span, which was placed in service a few weeks ago, is a riveted-truss through swing-bridge, 341 ft. long. The location of the new channel (partly to one side of the old channel) is such that the piers and abutments required for the new work could all be built without interfering with the old bridge masonry. This made it possible to carry through the entire erection without interrupting traffic, except that the line was closed during one day to make the change from old to new crossing.

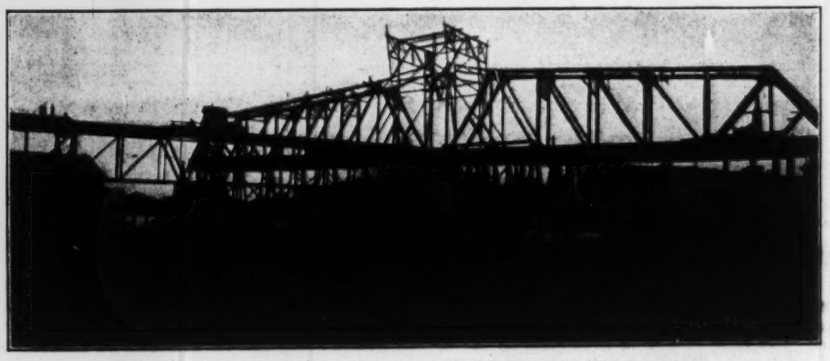


FIG. 2. VIEW OF OLD AND NEW DRAW SPANS BEFORE CHANGE.

In Fig. 1, a location plan of the site, the old bridge and its center-pier and abutments are indicated by dotted lines, while the new work is shown in full and broken lines. It may be seen that the two abutments of the new crossing, and also the new center pier, lie outside the limits of the old draw-bridge. The new crossing consists of the 341-ft. through-truss swing span, and a 60-ft. deck plate-girder span, the latter lying east of the draw. The junction pier, forming the east abutment of the new draw, lies under the old swing span. As the latter was a deck bridge, this pier could not be built up to full height, but only to the [illegible] chord of the old bridge, which gave occasion to use a novel means of supporting the new [illegible] when the change of crossing was made.

The course of the erection work was as follows. The roadway embankment west of the old [illegible] was replaced by a temporary trestle, extending beyond the new westerly abutment. The new center pier and the new east and west abutments—all of concrete—were completed to [illegible] height. As already noted, this work involved no interference with the old masonry. The junction pier, also of concrete, was carried up to the [illegible] of the bottom chord of the old draw. The [illegible] plate-girder span was built alongside its final location, on temporary supports, ready to be shifted into place as soon as the old draw was removed. The new draw span was erected on its own center pier, in a position oblique to the track, the diagonal bracing over the turntable and two of the tower posts were omitted temporarily to allow the passage of trains.

Fig. 2 shows the condition of things when the work was completed up to this point. In this view (looking south) the 60-ft. plate-girder span shows at the extreme left, in position on temporary supports. The new center pier, just behind the old west abutment, and the new draw in place on its falsework, are clearly seen, while in the background the temporary trestle and the new west abutment appear. Fig. 3, reproduced from a photograph of one arm of the new draw, shows the character of the new bridge.

When the work had progressed as far as possible without interruption of traffic, there remained four separate pieces of work to be done before the new bridge would be ready for use, viz.: (1) The 60-ft. deck plate-girder span was to be moved into place from its temporary support parallel to the track; (2) the old draw span was to be removed; (3) the temporary wooden trestle—on the right in Fig. 2—was to be torn down; and (4) the two remaining tower posts and connecting eyebars and bracing were to be placed in position in the new span. These four operations were entirely independent of one another and were carried on simultaneously by as many gangs of men.

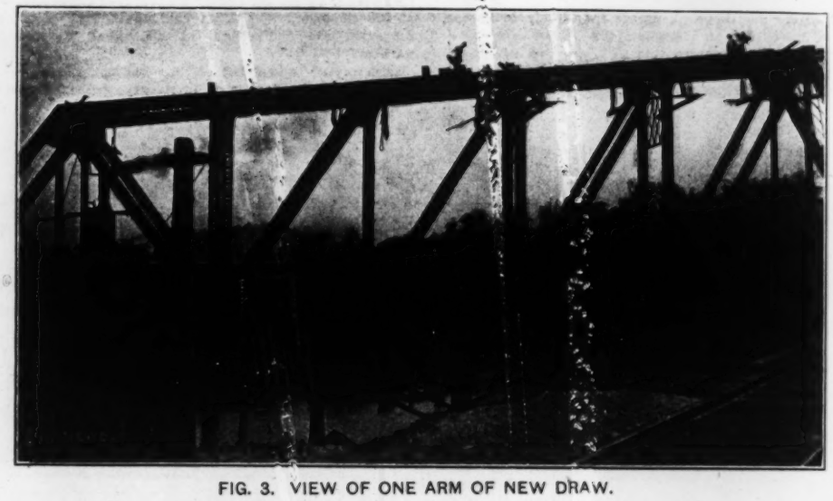


FIG. 3. VIEW OF ONE ARM OF NEW DRAW.

At daybreak in the morning of the day selected for the change, about 3 a. m., a gang of railroad men cut the track and began the removal of the rails and floor of the old bridge. At five o'clock, when the bridgemen began work, the floor had been removed and the bridge was then swung open to permit the placing of the barges which were to float it away. The barges, being partially filled with water, were pumped out by hand to float the bridge. The pumping began at 7:30 a. m. and was completed at 9, when the bridge was free from the old center pier. By this time, also, the plate-girder span had been moved to place, its outer end being supported by a timber bent, which was already framed and only needed to be raised and stayed against the (new) junction pier.

To carry the [illegible] of the new draw span on the

junction pier a set of concrete blocks had been made, to give a total height of about 11 ft. These blocks are shown, in place on the pier, in the sketch Fig. 4. The floor had already been placed on the short plate-girder span, and as soon as this span was moved over into position the rails were laid and connected up; a derrick car was then run out to the end of this span and the work

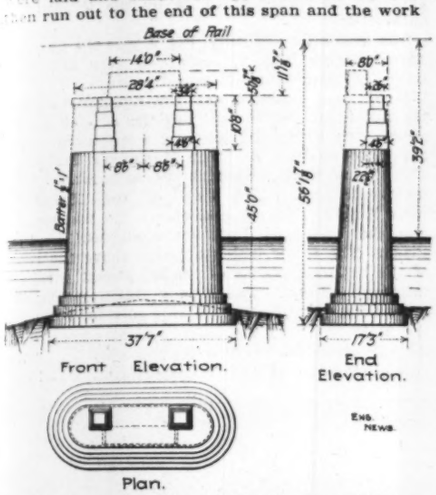


Fig. 4. Junction Pier for 341-ft. Through-Truss Swing Span and 60-ft. Deck Plate-Girder Span, Showing Concrete Blocking for Temporary Support of Swing Span.

of setting the concrete blocks was begun. The old draw was entirely out of the way at 11 o'clock, and at 2 p. m. the last concrete block had been set.

The trestle work occupying the west opening of the new draw was torn down with an engine by line and snatch blocks. This is shown in the view, Fig. 5. In the same view can also be seen the position of the new draw on its falsework, and the manner of suspending the erection-traveler from the bridge while swinging the latter into final position.

The work of connecting up the new draw span had been begun at 5 a. m., and was ready for the removal of the blocking at 11:30 a. m. At 4:30 p. m. the bridge was swung free from the

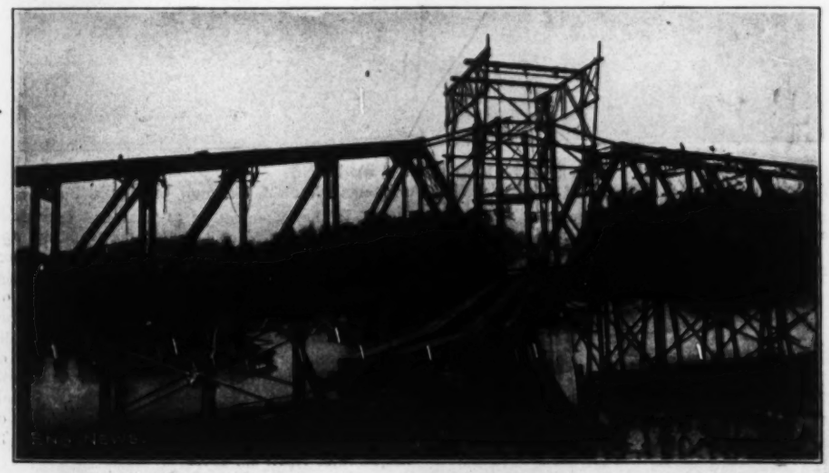


FIG. 5. TEARING OUT TEMPORARY TRESTLE BEFORE SWINGING NEW DRAW INTO POSITION.

falsework and at 5 p. m. it was closed. The first train passed over the new crossing at 9:50 p. m.

The junction pier was subsequently concreted to full height without removing the concrete blocks, these being left to form part of the pier.

Mr. E. E. Hart is Engineer of the New York, Chicago & St. Louis Ry. Mr. A. J. Himes is Bridge Engineer, and to him we are indebted for the data, drawings and photographs presented in the foregoing. Mr. Himes says of the work:

While the work was not very rapid, there was no miscalculation, and everything passed off without trouble or anxiety of any kind. Mr. Harry Fuller, engineer for the bridge company, was in charge of the work, and its successful completion is largely due to his efforts.

The bridge was built and erected by the King Bridge Co., of Cleveland, O.

FIRST CONVENTION OF THE AMERICAN PUBLIC WORKS ASSOCIATION.

In response to a notice sent to manufacturers, engineers, contractors and material men, a convention was held at Gulfport, Miss., Aug. 26, 1904. Mr. Edward J. O'Beirne, of Memphis, Tenn., called the meeting to order and nominated for temporary chairman Mr. M. F. Cole, who was elected. Mr. H. J. Malochee was elected temporary secretary.

The object of the meeting was then briefly stated by Mr. O'Beirne to be as follows:

Mr. O'Beirne said that several years ago the necessity for uniformity of specifications was apparent to him, and to other constructors and material men, owing to the wide difference of opinion among engineers, each framing his specifications to suit himself. The idea of a meeting of those interested, he said, was first suggested by the late Mr. Patrick Walsh, of Chattanooga, in 1900. That the object of the meeting was to organize a permanent association, and formulate a code of uniform rules, to be incorporated in all general specifications, pertaining to public work, which should be observed by the members of the association, so far as possible. That it was the intention that the rules should be fair and just to all concerned, and he believed their adoption by the engineers, contractors and material men interested in this particular business would result in better methods, lower bids and safer contracts. That it was the impression of some that this meeting was called for the purpose of "holding up" the towns or against the interest of certain lines, which was a mistaken idea, for no such intention existed, but on the contrary the organization to be effected and the rules to be adopted were intended for the protection of the interests of all concerned, including municipalities in general, and would tend to decrease the cost of public work. He said that a spirit of equity and fairness should prevail on both sides of all questions to be brought before this convention, and in the adoption of any rules or measures. He asked for a full, free and careful consideration of the latter, with the privilege of the floor to any one who desired to present his views.

After these introductory remarks the chairman appointed committees on Membership, Rules, Permanent Organization and Finance. The Committee on Permanent Organization presented the following recommendations:

1st. That this association be known as The American Public Works Association.

2d. That this association be a national body.

3d. That the association shall have four officers, viz.: a President, a Vice-President, a Secretary and a Treasurer. We submit for election:

J. A. Omberg, Jr. (City Engineer, Memphis, Tenn.), President.

Richard C. Houston (Cons. Engr., Laurel Miss.), Vice-President.

W. H. Flint (U. S. Cast-Iron Pipe & Fdy. Co., Chattanooga, Tenn.), Secretary.

H. J. Malochee (Glenny & Castanedo, New Orleans, La.), Treasurer.

4th. That there be an executive committee, elected for the transaction of business of this association.

5th. That the executive committee consist of five members, and that they shall hold office for one year, or until their successors are installed.

6th. That the executive committee shall draft suitable by-laws, rules and regulations to govern and transact the business of the association.

7th. That the executive committee shall have the power to appoint such committees as may be necessary in the conduct of the business of this association.

8th. That if the report of this committee be adopted the officers be immediately installed and take charge of the business of this association.

9th. That the temporary committee on rules, shall act as the executive committee of this association until such time as the permanent executive committee of this association shall be elected and installed.

The report of the committee was adopted, except the 8th section, which was struck out.

The Committee on Rules presented 57 rules, some of which were amended and many of which were rejected. The rules finally adopted were as follows:

1. When state or municipal statutes conflict with association rules the latter shall be waived.
2. When work is done on a percentage basis, security should be given to guarantee estimate and faithful performance of the work.
3. Designing engineer shall not compete for work advertised to be let under his plans and specifications.
4. No bids shall be asked until money to pay for the work has been provided.
5. Bids shall be opened and read in public.
6. No bids shall be submitted after time named in advertisement.
7. No bids shall be withdrawn after time set for opening of bids.
8. Illegibility, or ambiguity, shall invalidate a bid.
9. Bidders shall not be permitted to change prices stated in bid.
10. Bids shall state specifically, make of apparatus or machinery proposed, and same shall be specified in contract.
11. When all bids are rejected new bids shall not be made on the same specifications without readvertising.
12. The amount of certified check required shall be stated in advertisement calling for bids.
13. Bid bonds may be substituted for certified checks.
14. Checks or bid bonds shall be returned to all but successful bidder as soon as award of contract is made.
15. Award of contract shall be made within thirty days after bids have been opened or checks returned to bidders.
16. Bond shall not exceed 25% of contract price.
17. Twenty days shall be allowed contractor in which to furnish a satisfactory bond.
18. In event of discrepancies between the drawings and specifications decision of the engineer shall be final.
19. All instructions regarding work shall be given by the engineer or his assistants.
20. Extra work shall only be done on written order of engineer when authorized by contractee at a price to be agreed upon.
21. In deducting material not required only the value of same shall be deducted.
22. Changes in construction shall not be made to lessen quantities of material in transit or in process of manufacture unless contractor be paid for all actual loss occasioned.
23. When a specific make of machinery or apparatus is specified in contract same shall be furnished in accordance with manufacturer's plans and specifications submitted with bid.
24. Engineer or his authorized assistants shall at all times have access to the work and materials for purpose of inspection, and have notice of concealed work before it is covered.
25. In event of emergency work contractor shall notify engineer and engineer shall furnish inspector.
26. Work done in regular progress of the contract and ordered torn down for purpose of inspection, if found to be in accordance with the specifications, shall be at cost of contractee.
27. Engineer shall give written notice to contractor when work or material has been rejected.
28. Monthly estimate shall be made on or before the fifth day of each month.
29. Monthly estimate shall be based on the contract price and shall include all material delivered and labor performed.
30. Ten per cent. of monthly estimate shall be retained by contractee until work is completed.
31. Time shall be allowed contractor for delay caused by strikes, accidents or other causes beyond his control.
32. When work is completed engineer shall accept or reject same within a reasonable time.
33. Contractor is released from all future responsibility when contractee takes possession of plant, whether settlement has been made or not, unless otherwise agreed.

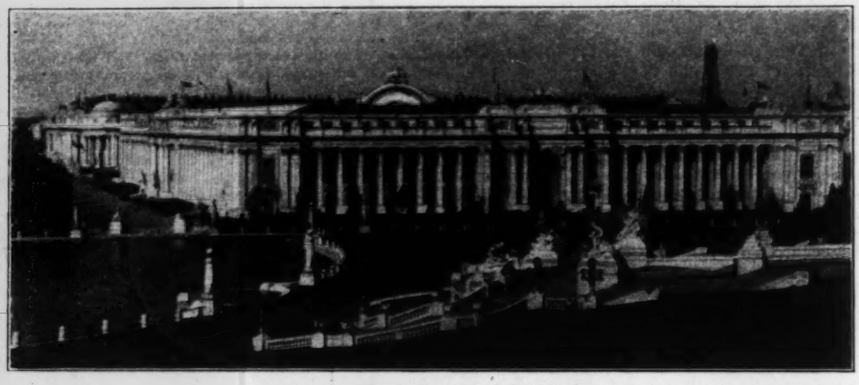


FIG. 1. EDUCATION BUILDING.
Barnett, Haynes & Barnett, Kansas City, Mo., Architects; J. J. Dunnavant Co., St. Louis, Builders.

34. When work is accepted the 10% retained shall be paid in final settlement, and bond shall be released and returned, except where a time guarantee has been agreed upon.
35. Arbitration shall be resorted to in all cases before applying to the courts.

NOTE.—In drawing specifications, if engineers will insert: "Work to be done under Rules of American Public Works Association," it will not be necessary to print rules in full in specifications.

At this the first meeting of the Association there were 42 men present, among them being contractors, engineers and representatives of manufacturing and supply firms. In addition there were 43 applications for membership. The meeting adjourned after passing a resolution thanking Mr. Edward J. O'Beirne for his efforts that have resulted in the organization of the American Public Works Association.

MINE SIGNALING BY COMPRESSED AIR has proved to be superior to other methods of signaling in the Le Roi shaft, according to a paper read before the Canadian Mining Institute by Messrs. Macdonald and Thompson. The system employed is merely the installation of the well-known Westinghouse compressed air train signal, in which the pulling of a cord operates a compressed air whistle. The system at the Le Roi mine has been in operation more than a year and a half without any repairs whatever. Regular Westinghouse apparatus as used on passenger trains was furnished by the Westinghouse Air Brake Co., and the entire cost of an installation to a depth of 1,000 ft., with signaling stations 100 ft. apart, was $125, including labor of installation. The apparatus has two distinct advantages over the ordinary bell-pull system: (1) Few moving parts, hence reduced liability of derangement; and (2) the signal sender has always a means of knowing whether his signal has reached its destination.

A WATER FILTRATION PLANT FOR MINNEAPOLIS has been recommended by a commission consisting of Andrew Rinker, City Engineer, F. W. Cappellen, M. Am. Soc. C. E., of Minneapolis, and Allen Hazen, M. Am. Soc. C. E., of New York City. Both slow sand and mechanical filters, were considered and estimates for plants at various sites were submitted. The committee, it appears, favored slow sand filters, covered, of some 30,000,000 gallons daily capacity, a 20,000,000-gallon covered clear water reservoir and a new pipe line. The filters would cost about $1,100,000. A citizen who donated a reservoir site to the city some years ago has offered to give 45 acres towards the 60 acres needed for the proposed new filters and extensions. It is expected that a popular vote on a bond issue for the proposed improvements will be held in November.

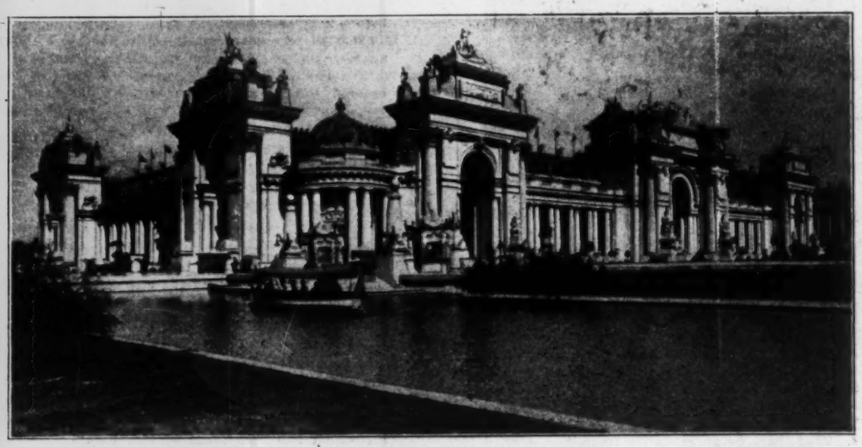


FIG. 2. LIBERAL ARTS BUILDING.
Eames & Young, St. Louis, Mo., Architects; Kellerman Construction Co., St. Louis, Mo., Builders.

THE BUILDINGS OF THE ST. Llouis EXHIBITION.

In architectural design, the main buildings of the St. Louis Exhibition compare well with those of other similar exhibitions, and we present herewith a series of views of some of these handsome structures, reproduced from a series of copyright photographs furnished to us by the Exposition authorities.

The Education Building, Fig. 1, and the Liberal Arts Building, Fig. 2, show two very different styles of treatment of long frontages. In the Liberal Arts Building are the headquarters of the American and French societies of civil engineers. The Electricity Building was illustrated in our issue of May 19. The Machinery Building, Fig. 3, has high towers at the corners and the main entrances. The view of the Manufactures Building, Fig. 4, also shows the waterway and the Louisiana Purchase Monument in the Plaza. The tower which appears above the roof of the building is that of the De Forest wireless telegraph system. The Mining Building, Fig. 5, has as one of its features a wide corridor between the main wall and the outer wall or screen, and its entrances are marked by tall obelisks. The special feature of the Transportation Building,

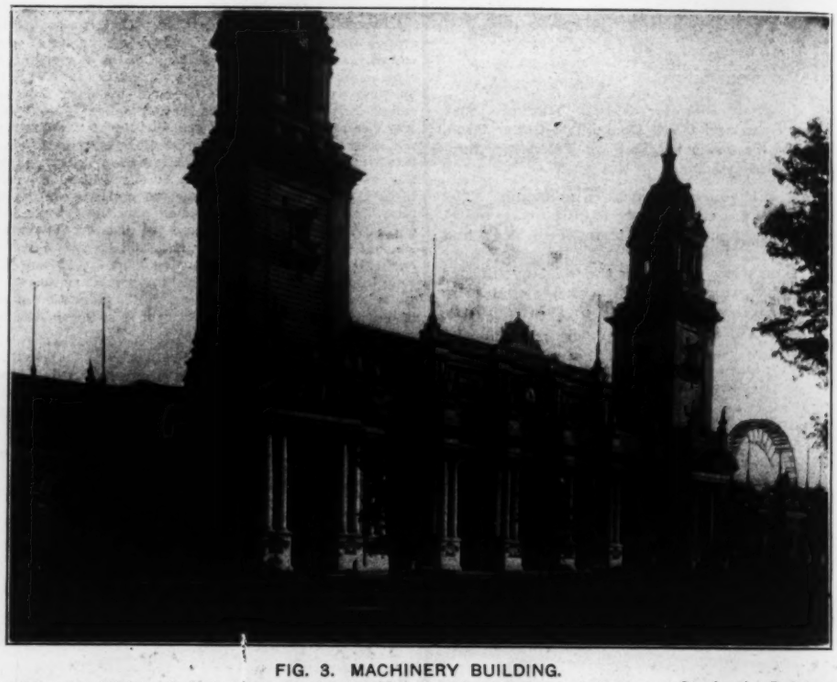


FIG. 3. MACHINERY BUILDING.
Widmann, Walsh & Boisselier, St. Louis, Mo., Architects; Smith & Eastman, St., Louis, Builders.

Fig. 6, is the triple set of high arched entrances. Fig. 7 shows the Varied Industries Building, and gives another view of the Louisiana Purchase Monument. The U. S. Government Building, Fig. 8, is of handsome classic design, and is located on rising ground, above the level of the central group of buildings. The view in Fig. 9 shows the beautiful Festival Hall, at the right, with one wing of the colonnade and the eastern pavilion. The main cascade falls from the front of the Festival Hall and the two side cascades start from in front of the pavilions. These cascades were described in our issue of April 23, 1903.

The structural work of these buildings was described and illustrated in our issue of May 19, and from that article we condense the following table of the main buildings, with their size and cost:

Building.	Size, ft.	Cost.
Agriculture	500 × 1,600	$529,940
Education	525 × 750	319,3[illegible]
Electricity	525 × 600	3[illegible],940
Fine Arts	350 × 175	600,387
Fine Arts (2 wings)	200 × 400	167,870
Fish and Forestry	300 × 600	173,000
Horticulture	300 × 800	228,872
Liberal Arts	525 × 800	475,000
Machinery	525 × 800	496,057
Manufactures	525 × 1,200	719,399
Mining & Metallurgy	525 × 750	498,000
Transportation	525 × 1,200	692,000
Varied Industries	525 × 1,200	660,000
U. S. Government	200 × 850	373,980
Festival Hall	.....	218,184

ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

A record-breaking number of members and guests met at Holyoke, Mass., on Sept. 14 to 16, at the annual convention of the New England Water-Works Association. The program was good and the interest in the sessions was maintained throughout. The local entertainment committee and the associate members took great pains in providing various amusements for the members and guests.

The most interesting items of business disposed of by the association, aside from the reading and discussions of papers, were the election of some fifteen ordinary and five honorary members and the appointment of a committee on uniform hydrant and hose nozzles, including threads. The committee was suggested, by letter, by R. D. Wood & Co., and will be composed of Geo. A. Stacy, of Marlboro, Mass.; M. F. Collins, of Lowell, Mass., and L. M. Bancroft, of Reading, Mass. The committee was authorized to cooperate with like committees from other water-works and from fire associations.

The honorary members chosen were: Desmond FitzGerald, Past Pres. Am. Soc. C. E., Brookline, Mass.; Prof. Wm. T. Sedgwick, Boston; Charles Hermany, Pres. Am. Soc. C. E., Louisville, Ky.; William Booth Bryan, M. Inst. C. E., London, England; and J. J. R. Croes, Past Pres., Am. Soc. C. E., New York City. Mr. Bryan was Engineer of the East London Water Co. until the transfer of the property of that and the other London companies to the (London) Metropolitan Water Board, a few weeks ago, and is now the chief engineer of that board.

FIG. 4. MANUFACTURES BUILDING.
Carrere & Hastings, New York, Architects; J. J. Dunnavant Co., St. Louis, Builders.

FIG. 5. MINES AND METALLURGY BUILDING.
T. C. Link, St. Louis, Architect; Hill & O'Meara Construction Co., St. Louis, Builders.

HISTORY OF THE WATER POWER OF HOLYOKE.

The first paper to be read was a historical account of the water power development on the Connecticut River at Holyoke. The paper was presented by Mr. Albert F. Sickman, Hydraulic Engineer Holyoke Water Power Co. The first dam across the river here was a timber structure, completed in 1849 and carried down-stream immediately after the gates were closed. A new timber and stone dam was built in 1849, and a new masonry dam was completed a few years ago.

During the construction of the first dam, in 1848, the workmen struck because their wages were reduced from 75 to 70 cts. per day.

PLEASING REMINISCENCES.

Mr. R. C. P. Coggeshall, of New Bedford, brought up to 1895 his interesting reminiscences of the association. Two years ago he presented a most entertaining review of the history of the association up to the middle of 1886. The earlier paper was published in the Journal of Association for December, 1902, and the later one occupies 30 printed pages of the Journal for September, 1904, which has been issued since the Holyoke convention.

THE ADDITIONAL WATER SUPPLY OF NEW YORK.

The work of the Burr-Freeman-Hering commission on an additional water supply for New York, as embodied in the report completed late in 1903, was reviewed by Mr. Rudolph Hering, M. Am. Soc. C. E. Mr. Hering stated that should there be one or two such dry years as were experienced recently the Croton supply would be exhausted. Important parts of the work of the commission were the analysis, in its behalf, of 15,000 samples of water; a sanitary survey of drainage areas; and detailed studies of the ground waters of Long Island.

MUNICIPAL WATER SUPPLY REVENUE.

The character of this suggestive paper was not very well indicated by its title. The author, Mr. James L. Tighe, Assoc. M. Am. Soc. C. E., City Engineer of Holyoke, presented an able argument against indirect taxation for municipal purposes in the form of what might be termed overcharges for municipal services. Starting with Adam Smith's maxim that taxes should be based on the ability of those taxed to contribute to the expenses of government, he showed, by illustrations from the records of Holyoke, how unevenly the burdens of taxation would be distributed if

FIG. 6. TRANSPORTATION BUILDING.
Isaac S. Taylor, St. Louis, Mo., Architect; H. W. Schleutter, St. Louis, Builder.

all or any part of the general expenses of a city were paid by water takers in the form of charges in excess of what is needed to render the water department self-supporting. He then argued that the water-works themselves, under public as well as under private ownership, should contribute towards the expenses of the city government in accordance with their ability, and announced that the city of Holyoke was in the unique position of taxing its own water department. To remove

FIG. 8. U. S. GOVERNMENT BUILDING.

J. Knox Taylor, Supervising Architect to the Treasury Department, Washington, D. C.; Strehlow & Phelps, St. Louis, Mo., Builders.

temptation from the city government to abuse this source of revenue by taxation, the special legislative act secured some two years ago provided that the taxes should be based on the cost of the water-works up to the previous year, less depreciation. All other city departments pay for water on the same basis as private consumers. Municipal ownership, as ordinarily practiced, removes private property from taxation and increases the taxation on remaining private property. All revenue-producing municipal works should in fairness be taxed.

Up to this point there had been practically no discussion on any of the papers presented, largely because they had been almost wholly descriptive in character. Mr. M. N. Baker, of the editorial staff of this journal, suggested that water rates should be based on benefits received by consumers and not, as in the case of regular taxes, on ability to pay. The plan of charging the various municipal departments for water, as practiced at Holyoke and too infrequently elsewhere, should be more extensively adopted.

A gentleman from Holyoke advanced as a justification for self-taxation of the water-works at Holyoke, that the water department had been acquiring land to protect the supply from pollution and that it was unfair to have so much land rendered non-taxable, as was the case before the new plan of taxation was adopted.

A WOOD STAVE CONDUIT FOR THE WATER SUPPLY OF ATLANTIC CITY, N. J.

Mr. Kenneth Allen, M. Am. Soc. C. E., Engineer and Superintendent of the Water Department of Atlantic City, N. J., described a 42-in. wood stave conduit, 9,807 ft. long, built between Feb. 4 and April 16, 1904, to replace an open canal at Atlantic City. An abstract of the paper, and of some appended notes by Mr. Myers, is given elsewhere in this issue.

Mr. W. C. Hawley, M. Am. Soc. C. E., of Wilkinsburg, Pa., who preceded Mr. Allen as water engineer at Atlantic City, stated that wood pipe was recommended by him and endorsed by Mr. Emil Kuichling, M. Am. Soc. C. E., for a force main at Atlantic City a few years ago, but the authorities decided to use steel instead. The history of the steel pipe in the salt marsh had seemed to justify the recommendation for wood pipe. Mr. Allen said, in reply, that the steel pipe seemed to be holding its own. The failure of wood pipe, however, would be less serious than the failure of steel, and he believed it was a great mistake not to use wood on the first line.

THE EPIDEMIC OF TYPHOID FEVER AT ITHACA, N. Y.

No paper on the program attracted more interest and no other one gave rise to as much discussion as did this. The interest was deep both because of the importance of the subject to water-works men and because the public has been waiting a long time for an authoritative report on the Ithaca epidemic. The author of the paper, Mr. Geo. A. Soper, Assoc. M. Am. Soc. C. E., represented the New York State Department of Health at Ithaca during the last part of the epidemic. Mr. Soper stated that before saying anything privately he had been waiting for the State to publish his official report, which it has failed to do.

The epidemic at Ithaca extended from Jan. 11 to April 15, 1903, and was doubtless due to the pollution of the water supply. In a population numbering 13,000 in the year 1900 there were, during the period named, 1,350 cases of typhoid fever and 82 deaths. The death rate, compared with many other epidemics on record, was low. This was partly due to the extensive use of laboratory methods of diagnosis, which resulted in detecting many mild cases. Mild cases are more dangerous to the public than severe ones, because the patients often continue to go about and spread the germs of the disease without check.

The cases at Ithaca were distributed fairly evenly over the whole city, except that they finally became more numerous than elsewhere on East Hill, the residence section for College students. The students contributed heavily to the number of cases because persons between the ages of 16 and 25 years are particularly susceptible to the disease.

Mr. Soper described the sources of the water supply of both the private water company and the university. While it was true, as reported at the time, that no cases of typhoid were recorded in buildings on the university water supply, the lantern slides shown by Mr. Soper made it evident that the university supply was in constant danger of pollution from privies. The most appalling views thrown on the screen, however, were those showing numerous privies overhanging or close by the streams from which water was drawn by the water company. A few years ago the company spent a large sum of money to prevent pollution, but for three of four years past nothing appeared to have been done to that end. No less than 17 privies were found on Six-Mile Creek, within the limits of Ithaca, and only a few rods above the intake of the water company. Eight cases of typhoid fever, occurring within twelve months of the epidemic, were located on the drainage area of the same stream. Heavy rains occurred two weeks before the outbreak of typhoid.

Mr. Soper arrived in Ithaca on March 2, and although representing the State Department of Health, the work done under his direction was carried on by the local board of health. Among the measures taken were (1) cutting off, so far as possible, the polluted water supply and delivering pure water to houses at 1 ct. per gallon. Even this charge was waived where poverty demanded; (2) preventing the spread of the disease from person to person; (3) general sanitary improvement. Both the water company and the university constructed mechanical filtration plants as rapidly as possible, and the citizens undertook to develop an underground supply of water. Rules for conserving the purity of the old supplies were made and the registration of vital statistics was improved.

A total of 1,200 private wells were found. Of these, 1,100 had been examined and some found polluted, when the local board, as a matter of economy, stopped the examination. That this proved to be poor economy was soon shown, for a local outbreak of 70 cases of typhoid, resulting in four or five deaths, soon occurred, and this outbreak was traced to one of the uninspected wells. This particular well was freely used by neighbors. It was found that a house sewer passing within 4 ft. of the well was discharging sewage into the ground through a defective joint.

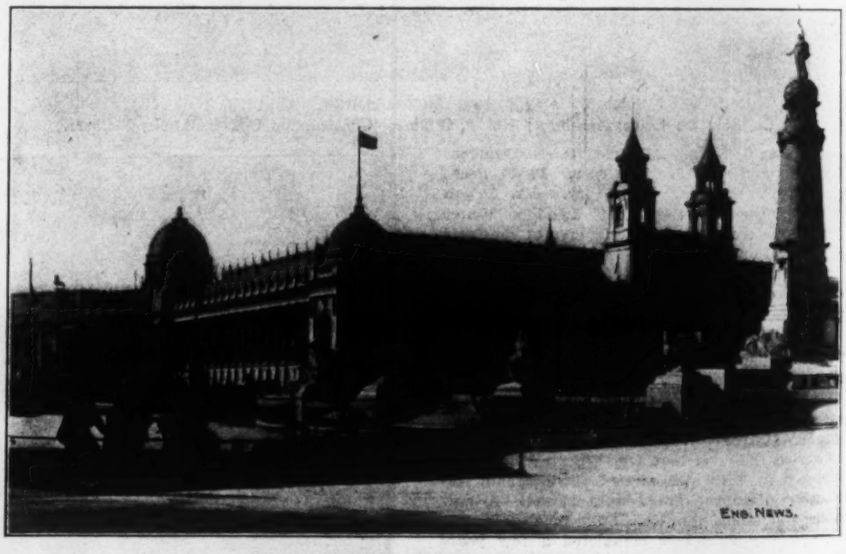


FIG. 7. VARIED INDUSTRIES BUILDING.

Van Brunt & Howe, Kansas City, Mo., Architects; Rountree Construction Co., St. Louis, Mo., Builders.

...ial tests of blood from a woman living in this ...se, who had been sick, but whose illness was ...ributed to la grippe, showed that she had had ...noid fever.

The 1,350 cases of typhoid at Ithaca were lo...ted in 522 houses. In 151 houses there was a ...al of 420 cases and in a single house there ...ere nine cases.

In discussing the paper, Mr. L. M. Hastings, of ...mbridge, Mass., stated that the water board of

FIG. 9. FESTIVAL HALL.
Cass Gilbert, New York, Architect; Strehlow & Phelps, St. Louis, Builders.

his city had built privies in its drainage area, at its own expense, to protect its water supply. Prof. E. G. Smith, of Beloit, Wis., gave some particulars regarding water-borne typhoid at Rock Island, Ill., and Baraboo, Wis., the latter due to defective joints in pumping mains beneath a river. Mr. M. N. Baker said that the conditions described as previously existing at Ithaca were appalling, particularly in view of the fact that like dangers were hanging over other communities. The lessons of the Ithaca epidemic might be considered under two heads: The duties of water-works officials and of boards of health. Water-works men should do all they could to prevent pollution and to secure purification, where needed. Boards of health should improve their systems of registering vital statistics and the character of the work of their health inspectors. The difficulties of securing properly trained health inspectors suggested the need of courses of instruction, at technical schools, that would fit men for such work.

The difficulties involved in preventing water pollution, combined with the recent numerous typhoid epidemics, suggest that the time is near or has come when all surface water supplies should be purified, as is done in Germany and in England.

Three questions were suggested for answer by Mr. Soper in his written discussion: (1) Why had his official report on the Ithaca epidemic not been published? (2) How could such conditions as he had described prevail in a university town, where some of the professors might be expected to guide public opinion to the adoption of protective measures? (3) Has Ithaca an efficient board of health to-day? The failure to publish the report on the Ithaca epidemic was to be deeply regretted, inasmuch as the report forms such an object lesson for other communities. The report should have been printed and then distributed broadcast throughout New York State.

THE USE OF SUPERHEATED STEAM IN PUMPING ENGINES.

A paper on this subject was read by Mr. E. H. Foster, M. Am. Soc. M. E., of New York City. The relatively high cost of fuel in Europe is doubtless largely responsible for the greater use of superheaters there than in America. Superheaters are particularly adapted to use with pumping engines. A saving of 6% may be expected on duties of 150,000,000 ft.-lbs.; 10% on 100,000,000; 20% on 40,000,000; 40% on 10,000,000 ft.-lbs.

OTHER PAPERS.

"Bog Fuel" was again brought before the association by Mr. Edward Atkinson, of Boston. He stated that years ago he took out a patent for making briquettes from peat or bog mud and that these patents, long since expired, had prevented Europeans, whose briquette machines are similar but later, from getting American patents. His later investigations, which he described, are being made public as rapidly as definite conclusions are reached in order to forestall monopoly patents. A third and final bulletin on bog fuel investigations will soon be issued under Mr Atkinson's direction.

The paper on the "Norwich Compressed Air Plant," by Mr. J. Herbert Shedd, M. Am. Soc. C. E., of Providence, went over about the same ground as was covered in the description of the plant, which appeared in Engineering News of June 12, 1902.

"The Holyoke Water Supply," by Mr. A. M. French, of Holyoke, the "Description of the Haskell Brook Reservoir Dam," by Mr. Herman W. Spooner, of Gloucester, and "Direct Pumping Method of Water Supply in Use at Taunton, Mass.," by Geo. A. King, were good papers of the descriptive class. A number of other papers on the program were not presented, owing to the failure of their authors to appear.

On behalf of the committee on private fire services Mr. R. J. Thomas, of Lowell, reported that the water board of his city is now testing various devices for measuring water for fire purposes; that the board had an excellent installation for making such tests and is willing to test any device for the purpose named.

FLANGE WEAR AND SIDE BEARING TRUCKS.*

By Gustav Lindenthal,† M. Am. Soc. C. E.

The complaints about sharp flanges on car wheels, which in the past had not been infrequent, have become in the last few years more numerous and serious, under the extra heavy cars now in use. Broken flanges also occur, perhaps not more frequently, but they seem to be the cause of more numerous freight wrecks than before.

With the greater wear of wheel flanges, there has been observed also a very much increased wear on the inside flange of the outside rail of curves, necessitating more frequent renewals of these rails. Experiments have been made with nickel steel rails on curves, with good results. They wear about three times longer than ordinary steel rails, and although they cost twice as much, at that rate of wear they still represent a considerable economy.

But no remedy has yet been found for the excessive wear of wheel flanges, and this inquiry is directed towards finding out whether and in what direction a remedy may be found.

1. The flange wear of rail and wheel is nearly absent on tangents and is greatest on sharp curves. A great lateral pressure is exerted on curves through the wheels against the outside rail, for which three causes may be assigned: Centrifugal force, the force required for deflecting the direction of the wheels fixed on axles from a straight line, and, third, the frictional resistance of the center and side bearings on the truck. Let us examine them separately:

2. As the first cause, centrifugal force, a glance will show that it is so small as to be negligible. The usual superelevation of the outside rail on curves is adjusted for average speeds, at which the resultant of load and centrifugal force passes through the center of the track. In that case there is no lateral pressure against the rails, because the track is inclined at a right angle to the resultant, as shown in Fig. 1. There is of course a lateral pressure from the inclined tie transmitted to the ballast foundation, but it does not affect the rails.

If the speed is greater or smaller than the average, then the resultant will move nearer the outside or the inside rail, exerting then a relatively small direct lateral pressure against one or the other. But inasmuch as the lurching and swaying of the car brings pressure upon the side bearings of the truck, the friction here will hinder the truck from turning freely, and in that way an excess or deficiency of centrifugal force may be the cause of considerable flange pressure. That point will be considered further on in connection with side bearings.

3. More important is the lateral pressure upon the rail resulting from changing the direction from a straight line into and around a curve. The truck of a heavy freight car will be taken here as typical and as including hereinafter the similar observations on other kinds of cars and on locomotives.

It is a well-established fact, first discussed by A. M. Wellington, in his work on Railway Location, that the front outside wheel of a truck is the only one in lateral contact with the rail. The flanges of the three other wheels do not touch the rails. Fig. 2 shows the normal position of the truck on a curve, for which the rear axle assumes the radial position.

The truck with rigid frame and with the wheels rigidly fastened on the axles has the tendency to run in a straight line. On a curve it requires a large lateral force to move the wheels sideways from a straight line. If the wheels were loose on the axles, and if further the axles could assume a radial position, then the truck would exert no more lateral pressure upon a curve than it does on the tangent. Flange wear of wheels and rails would then be unknown. But the construction of trucks and locomotives with radially swivelling axles is impracticable, and the

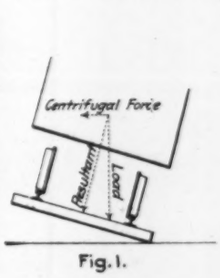


Fig. 1.

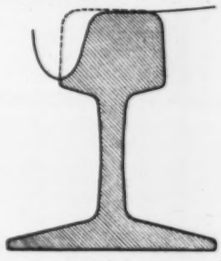


Fig. 5.

finding of a remedy in that direction against excessive flange wear would be fruitless.

4. With the four-wheel truck, the work of turning the car from a tangent into and around a curve falls upon the outside front wheel, through which the entire lateral pressure of the truck against the rail is exerted. The front wheel assumes the office of pushing the three other wheels of the truck sideways from a straight line, in which they otherwise would continue to roll. The slippage of the wheels by reason of their inability of turning

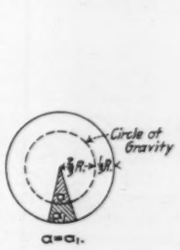


Fig. 4.

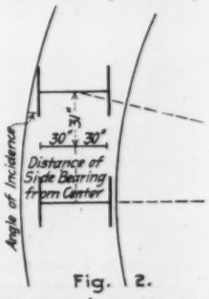


Fig. 2.

on the axles has no appreciable influence upon lateral pressure.

Assuming one of the recent heavy coal cars uniformly loaded, total weight 100,000 lbs., we have on each wheel 20,000 lbs. With a coefficient of sliding friction of 0.25, the flange pressure on the front outer wheel of each truck will therefore be 3 × 20,000 × 0.25 = 15,000 lbs. (or 30,000 lbs. per car). This lateral pressure is independent of the degree of curvature, but it is in direct proportion to the weight and load of the car.

*A paper read before the New York Railroad Club, Sept. 16, 1904.

†Consulting Engineer, 45 Cedar St., New York City.

5. If the outer front wheel were normal to the radius of the curve, there would be little flange wear, because the resultant of the vertical and lateral pressure would pass obliquely through the corner of the rail, and through the neck of the wheel flange. The flange itself would not be pressed against the side of the rail. There would be here only rolling friction along the inner edge of the rail. With new rails and new wheels, that is actually the case. Flange friction and train resistance on curves is known to be very much less with new rails than with old, worn rails. But as the outer front wheel is not normal to the radius, its flange forms an angle with the rail (the angle

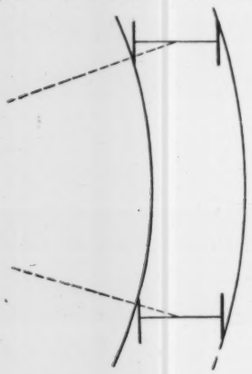


Fig. 3.

of incidence). There is then side contact betwen flange and rail and rubbing friction. It increases with the angle of incidence, that is with the degree of curvature, although the lateral pressure against the outside rail is the same on sharp curves as on light curves. The only way in which, for the usual center bearing truck, the lateral pressure from that cause (continuous change of direction on curve) could be reduced would be by lubricating the top of the rails on curves, reducing the coefficient of sliding friction from 25% to less than 3% of the vertical pressure. That, however, is impracticable. The wheel treads would of course become greasy, and the tractive power of the locomotives and the holding power of the brakes would be greatly reduced. It is a choice of evils, and flange wear is the smaller of the two.

6. The length of wheel base has an important bearing upon flange pressure. If the base be long, as in a European car, without trucks, then the work of turning the car is performed by the front outer wheel and the rear inner wheels. The car or truck assumes then a position normal to the radius of the curve, as shown in Fig. 3. Both these wheels have flange pressures, which for each wheel is less than the flange pressure upon the front outer wheel of a shorter wheel base, as in the American truck. But the angle of incidence is greater, and both the outer and inner rail are subject to lateral pressure. Therefore, on European track, both rails on a curve show wear at the inside flange, while on American track the rail-flange wear is confined to the outer rail.

It is clear that when the rear inner wheel participates in the work of turning the truck or car around the curve, the front outer wheel will be exposed to less lateral or flange pressure, and therefore to smaller flange wear. Therefore a longer wheel base than is usual for four-wheel trucks (5 to 6 ft.) would have certain advantages in that respect. I believe it is considered a fact that the

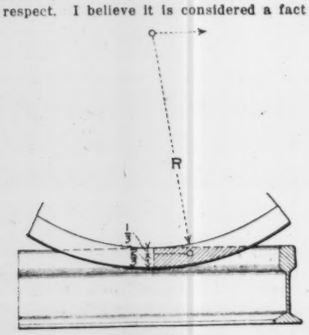


Fig. 6.

wheels of the longer six-wheel trucks show proportionately less flange wear.

7. We will now consider by itself the friction of the center bearing on the truck. Tests have been made on the friction of center bearings by W. C. Squire, reported in the Proceedings of Western Railroad Club, 1898.

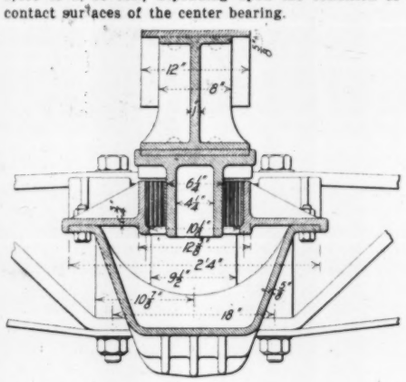
From the tabulated results I select the pressure on center plate of 50,000 lbs. The power P required with a leverage of 31 ins. varies from 3,044 lbs. for rough, unlubricated surfaces to 897 lbs. for rough, lubricated contact; 31 ins. is the distance given between center of plates and the horizontal axis of the axle. (See Fig. 2); but the diameter of center plate is not given. Assuming the same at 9 ins., which is the prevailing size, we can readily determine the coefficient of friction. The distance of gravity line for a circular area is equal to 2-3 radius; (See Fig. 4) for a diameter of 9 ins. it is equal to 3 ins. from center. For the frictional resistance of the load L on center bearing we have $f L = 31 P \div 3$, or $f = \frac{31 P}{3 L}$.

For unlubricated rough surfaces..$f = \frac{31}{3} \times \frac{3044}{50000} = 0.627$.

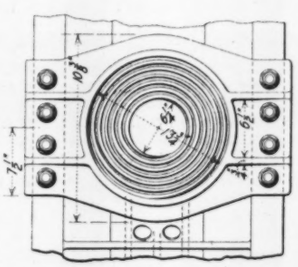
For lubricated rough surfaces ...$f = \frac{31}{3} \times \frac{897}{50000} = 0.185$.

A fair mean value taken from Mr. Squire's table would be $f = \frac{31}{3} \times \frac{1625}{50000} = 0.334$. The coefficient of friction may therefore vary from 62 to 18%. 35% is a fair average value, which agrees with observation and with the theoretical assumptions on center plate friction made heretofore.

Returning to our car with a total weight of 160,000 lbs., the load on each center plate may be assumed at 72,000 lbs. (without the weight of truck). For such a heavy car the center plate will be 12 ins. in diameter. The distance of gravity circle from center will be 4 ins. The distance from center to axle in a truck of 5 ft. 6 ins. wheel base will be 33 ins. Therefore, lateral pressure p on outer front wheel from friction of center bearing $p = \frac{4}{33}$ 72,000 x 0.35 = 3,060 lbs., as an average, but taking the highest and lowest values, deduced from Squire's experiments, the lateral pressure against the rail may vary from 5,600 to 1,500 lbs., depending upon the condition of the contact surfaces of the center bearing.



Section through Center Pin.



Plan of King Pin Plate.

8. The center bearing never carries the entire load on the truck for any length of time, even with stout car and truck bolsters. The lurching of the car caused by uneven track and defective rail joints is quite noticeable on tangents and still more so on curves. It does no harm when on a tangent, but it adds very much to the curve resistance.

Let the speed be increased, or the center of gravity of the loaded car be higher than the assumed average, then a great change results at once in the behavior of the center bearing car truck.

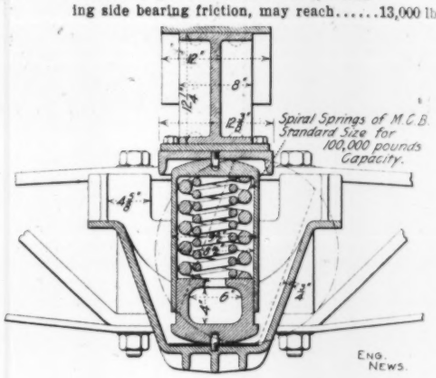
Assuming that, through unbalanced loading or through lurching, one or the other side bearing carries one-fourth and the center bearing carries three-fourths of the load of 72,000 lbs. That is 18,000 and 54,000 lbs. respectively. The side bearings are each 30 ins. from center. (See Fig. 2.) We have in this case a flange pressure $p = \frac{(30}{33}$ 18,000 + $\frac{4}{33}$ 54,000) 0.35 = 8,029 lbs., which is more than 2½ times the flange pressure from center bearing alone. If, as frequently happens, with weak framed and overloaded cars, the side bearings carry one-half the load, the flange pressure may reach $\frac{(30}{33}$ 36,000 + $\frac{4}{33}$ 36,000) 0.35 = 12,971 (or say 13,000) lbs. It is thus to be seen that sliding friction side bearings may increaes the flange pressure to more than four times the flange pressure on center bearing alone.

9. It is usually assumed that the flange pressure against the rail, due to friction of the center and side bearings occurs only in entering and leaving a curve. But this view is misleading because it leaves out the spring or elasticity of the truck against turning in the center bearing. If the truck were perfectly rigid, then the motion of the center bearing would take place only on entering or leaving the curve. But the fact is that the truck must pass through a certain elastic deformation before the friction of the center bearing is overcome; just as a crowbar must bend some before it will take a "bite" under a load.

The result for the truck is that the lateral pressure against the rail, required to overcome the friction of the center bearing (or of the side bearings, if they are loaded), is more or less *continuous* throughout the curve. After leaving the curve the truck tends to turn back again into the normal position for the tangent, but here again the elasticity of the truck furnishes resistance and causes lateral pressure and flange wear for a certain distance on the tangent. We have here the explanation for the well observed fact of flange wear on the inside rail of tangents at the end of curves, which is puzzling to some trackmen.

10. Let us now recapitulate the separate values of lateral pressure on curves and we have for the assumed load of a freight car, weighing 160,000 lbs., the following amounts per single truck:

(1) From centrifugal force, nil.
(2) From change of direction, with fixed wheels.15,000 lbs.
(3) From friction of center bearing, average.... 3,000 lbs.
which may grow to 5,600 lbs. and, including side bearing friction, may reach.....13,000 lbs.



Section through Rolling Side Bearing.

FIG. 8. LINDENTHAL SIDE BEARING TRUCK FOR 100,000-LB. CAR.

That is, the outer front wheel of each truck in a modern heavy freight car may exert a lateral pressure against the rail varying from 18,000 to 28,000 lbs., when the vertical pressure upon the wheel is 20,000 lbs. under a car weighing 160,000 lbs., or, in other words, for each 100 lbs. vertical pressure there is from 90 to 140 lbs. lateral pressure under the front outer wheel, or, applying the relation to the whole car, the lateral pressure is from 22½ to 35% of the load of the car, be it light or heavy.

Several instructive conclusions can be drawn from this analysis:

11. The outer rail on a curve is subject to a lateral pressure, which is from 45 to 70% of the vertical wheel pressures, assuming both pressures distributed upon a rail 30 ft. long.

Deducting coefficient of friction of rail upon wooden ties at 30%, we have 15 to 40% of the lateral pressure left to be resisted by the rail spikes. We need not wonder that the spikes in hardwood ties are sawed off gradually, and that on soft wood ties the outside rail has a dangerous tendency to spread.

12. On new outside rails the resultant of vertical and lateral pressures from the outer front wheels has to overcome only rolling friction. But very soon the corner of the rail is abraded (see Fig. 5), and while the vertical pressure continues to cause only rolling friction, the lateral pressure against the side of the rail gradually causes rubbing or sliding friction, the coefficient for which is probably 100 times greater than that of rolling friction. The side of the rail head may therefore grind off faster from sliding friction than the top of the rail can wear from rolling friction. Naturally this sliding friction wears off also the wheel flange of the outer front wheel. But each wheel in a truck is at one time or another an outer front wheel, so all wheels wear more or less alike. Assuming that the metal of the wheel tread and flange is twice as hard and rough as the ordinary steel rail, which assumption is near to fact, then for every ounce of metal ground off the flange

wheel two ounces of steel are ground off the inner of the outer rail of curves.

pointed out before, because of the angle of incidence flange wear of outer rails is greater on sharp curves on flat curves. Just how much greater it is difficult ey.

we had to deal with conditions of mathematical exact- then that wear would, for instance, be twice as great 6° curve as on a 3° curve. But with trucks as hly made as they usually are, a reliable rule in that d cannot be made.

The rubbing or sliding friction of flange pressure ts the tractive force required for hauling the car. For p worn flanges 1½ ins. deep, in rubbing contact with side of the rail, the frictional resistance may be quite large. The wheel flange fits tightly against the rail head, which is sometimes more than half its h ground off. The vertical contact area between rail wheel flange is a triangle, as shown in Fig. 6. The ter of gravity of that area will be ½-in. below top of il, which can be taken as the fulcrum with the radius of heel (15 ins.) as lever. If the flange pressure under that med 160,000 lbs. car be taken only as $2 \times 18{,}000 = 36{,}000$ lbs., then we have for a coefficient of friction of 0.25 a resistance $R = 0.25 \frac{0.5}{15} \times 36{,}000 = 300$ lbs., added to the ordinary tractional resistance of that car. It may occasionally reach (for 56,000 lbs. lateral pressure per car) 420 lbs. For level grades and straight line, the tractional resistance is usually taken at 4 lbs. per ton, which would be 470 lbs. for the car weighing 160,000 lbs. The flange pressure would therefore nearly double that resistance, raising it to 8 lbs. per ton on a level grade, which closely accords with observed fact on worn curves.

14. The flange pressure reacts also upon the car axles, which are usually proportioned only for vertical loads and impacts. Taking a 6-in. axle, its moment of resistance R is very nearly $\frac{d^3}{10} = 21.6$. Taking the vertical load P of 20,000 lbs., and the distance from center of journal bearing to center of hub as 8 ins., we have an outer fiber stress of $\frac{8 \times 20{,}000}{21.6} = 7{,}400$ lbs.

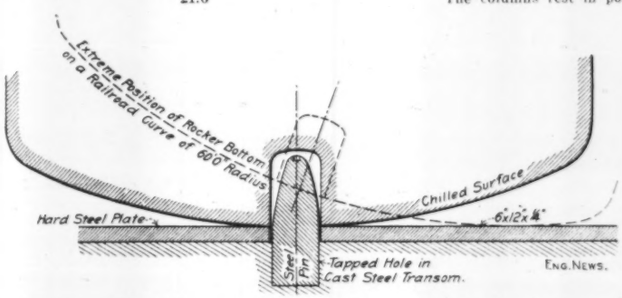

Extreme Position of Rocker Bottom on a Railroad Curve of 600' Radius
Chilled Surface
6x12x4"
Hard Steel Plate
Steel Pin
Tapped Hole in Cast Steel Transom.
ENG. NEWS.

FIG. 7. SECTION THROUGH CONTACT SURFACE OF ROLLING SIDE BEARING.

The outer fiber stress from lateral pressure will be $\frac{18{,}000 \times 15}{21.6} = 12{,}500$ and may reach $\frac{28{,}000 \times 15}{21.6} = 20{,}000$ lbs. per sq. in., showing that the axle may be strained higher from the lateral pressure on curves than from vertical pressures. And as both pressures are simultaneous, the outer fiber stress may reach (7,400 + 20,000) = 27,400 lbs., without torsional stress and without allowance for impact, which may double that stress, so that at times it may reach 55,000 lbs., alternating tension and compression, which is very near the elastic limit of axle steel. Loaded coal and iron ore cars weigh frequently more than 160,000 lbs. We have here a theoretical explanation for the overstraining and occasional fracture of apparently sound axles.

15. I have already indicated that car trucks are subject to severe diagonal stresses. The flange pressure from the outer front wheel must be transmitted to the other three wheels and to the center bearing through the truck framing, without any members in the direct line of the pressure. It must be transmitted indirectly through the diamond frame and through the truck bolster, both exposed to bending moments tending to distort the truck, and bringing heavy secondary stresses upon its connections, which are, as a rule, much too weak to resist them.

The lateral spring, or elastic resistance, which I mentioned above, is unavoidable, and the flange pressure from it constantly present upon curves.

From all the foregoing discussion, the conclusion can hardly be escaped that the trucks have to resist much larger stresses, both vertically and laterally, than are usually allowed for in their construction, and that almost all known truck constructions are too weak. We need not be surprised, therefore, at the frequent and costly repairs, particularly of freight car trucks.

16. The question arises how the lateral pressure, so detrimental to truck and track on curves, may be reduced. That portion (15,000 lbs. for the heavy car) arising from the wheels being rigidly fixed upon the axles, throwing the work of deflecting them around the curve upon the outer front wheel cannot be wholly eliminated, but it may be possible to reduce it. If the impulse upon that wheel from the friction of the center plate could be lessened, then the rear outer wheel could come up closer to the rail and thus relieve the flange pressure upon the front outer wheel. The angle of incidence would then be also reduced. Each of these two outer wheels would then exert a lateral pressure against the rail, although it may not be the same on both. A large share of that lateral pressure may still be left to the front outer wheel, but instead of the 15,000 lbs. in the case of the heavy car, used for illustration, there would perhaps be only 10,000 lbs., or even much less lateral pressure

Any device that will reduce the friction of the center and side bearings will very probably also reduce that part of the flange pressure. How much, it would be impossible to say without extended tests, but a reduction of 30% is not improbable with the device hereinafter described.

One of the means already used and tested is the greasing or lubrication of the center plates on the trucks, also of the side bearings. A very considerable reduction of flange pressure and flange wear has been observed with it. But the inconvenience of lubrication and the difficulty of keeping it up have been found to be great impediments. A better plan is the doing away entirely with center bearings and to rely upon nearly frictionless side bearings alone. A suitable construction of this kind is shown in the accompanying sketches.

17. The side bearings consist in principle of large cast-iron balls (about 26 ins. in diameter) on which the car body rests, two such balls, as a rule, for each truck. The sides of the balls, being useless, are cut away, so that the form is that of columns or rockers, with spherical ends, which have hard chilled surfaces. In place of the center bearing there is a center pin or pivot, having a loose fit in a spring socket. It can take no vertical pressure, but the spring socket protects the pivot and so the truck frame against lateral shocks. The columns rest in pockets, one at each side of truck. The columns may have different forms. They may be rigid, or each column may consist of two telescopic parts containing inside spiral springs, giving it the action of a rubber ball. There is only rolling or ball friction at top and bottom of these columns, the coefficient of which friction will hardly exceed 1-1,000, even with unmachined surfaces, liable to get gritty with cinder and dirt. Reverting again to the heavy freight cars for illustration, and taking the weight on the rockers at each car end at 72,000 lbs., the rolling friction of both side bearings will be about 72 lbs.

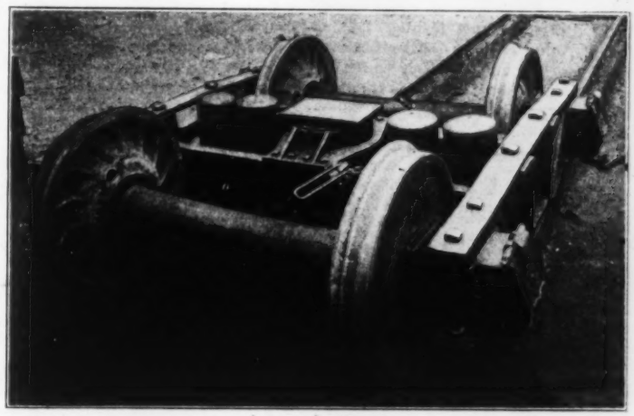


FIG. 9. PERSPECTIVE VIEW OF LINDENTHAL TRUCK WITH DOUBLE SIDE BEARINGS.

The lateral or flange pressure per truck from that cause alone will then be $\frac{30}{33}$ 72 lbs. = 66 lbs. against 3,060 lbs. with the center bearing, as stated in Section 7. That is, in the proportion of 1 to 46. Moreover this small resistance from the rocker side bearings will only occur on entering and leaving the curve, whereas in a center bearing truck the friction of the center plate causes that flange resistance to continue throughout the curve, as already explained in Section 9.

18. If that portion of the flange pressure discussed in Section 4 and Section 16 (arising from fixed wheels) can be reduced from 15,000 to 10,000 lbs., as it most likely will be with the rocker side bearings, we would then have a total flange pressure of $10{,}000 \times 66 = 10{,}066$ lbs. against the former total of 18,000 to 28,000 lbs. (Section 10), that is from 40 to 65% less.

As the flange wear is in direct proportion to flange pressure, there would be a saving of 40 to 65% in the wear of wheel flanges. The flange wear of rail heads would also decrease, but would not be noticeable, unless all trucks or a large proportion were rocker side bearing.

19. The reduced curve resistance by reason of decreased flange pressure would permit of hauling, with the same locomotive in any given train, more cars, when equipped with nearly frictionless side bearings.

One additional car for every five cars now hauled may be regarded as a moderate estimate from the analysis given above.

Other advantages of rocker side bearing trucks are the doing away with the car and truck bolsters, permitting of a simpler and lighter construction, and the prevention of the disagreeable rocking and swaying of the car, so characteristic of the center bearing truck. The side bearings give a more even and steady car motion, freer from jolts. Where the car is extra heavy, then in place of two rockers on each truck four are used, as shown on plan.

20. The first trucks built on this principle a few years ago had spiral spring bearings above the journal boxes, and the rockers consisted of solid cast iron. The second instalment was built on the modified plan, and further improvements of details have been made, with the object to insure greater vertical flexibility of the truck frame on rough and uneven track.

Careful estimates and comparison of weights show that the side bearing truck is lighter in weight than an equivalent center bearing truck. It consists only of a few compact parts, and it has no riveted connections. The only parts requiring renewals from time to time will be the wheels, axles and journals.

The feeling of practical railroad men in favor of nearly frictionless side bearings is thus theoretically justified. The above analysis points the way to a more scientific construction of the car truck, as shown.

ANNUAL CONVENTION OF THE ROADMASTERS' AND MAINTENANCE-OF-WAY ASSOCIATION.

The annual convention was held at St. Louis, Mo., Sept. 13 to 15, the meetings being held in the reading room of the Transportation Building of the St. Louis Exhibition. The first meeting was opened about 11 a. m., Sept. 13, when an address of welcome was delivered by Mr. Willard Smith, Chief of the Department of Transportation.

THE CHEAPEST METHOD OF DITCHING CUTS AND WIDENING EMBANKMENTS.—After some routine proceedings this committee report was read by the secretary. It brought out very little discussion, but the secretary explained that the figures of cost in the report represented the results of actual experience on the Baltimore & Ohio Southwestern Ry.

TRACK IMPROVEMENTS AND MAINTENANCE OF WAY EXPENSES.—This paper was presented by Mr. E. E. R. Tratman (Associate Editor of Engineering News), and was on the line of the editorial on "Needed Improvements in Track Construction and Maintenance of Way," published in our issue of Sept. 8.

RAIL FASTENINGS.—This was the subject of the next paper, by Mr. A. Morrison (Cambria Steel Co.). It was a rather surprising laudation of the track spike as compared with improved fastenings, and the fact that "we still have the spike almost if not quite in its original shape" was given as a point in its favor. Certain unsuccessful experiments with screw spikes were also cited.

TIE PLATES.—A report on this subject was prepared by Mr. C. E. Jones, the Secretary, on account of the failure of the committee to submit a report, and an abstract of this is given below:

Tie plates are now considered standard track material, and their use is generally known and appreciated.

There are three distinct classes or kinds of tie plates—non-adhesive, longitudinal flange and cross-grain claw.

The first of these cannot perform the first requirement essential to a tie plate; that is, to become a part of and act with the tie in its behavior under passing loads. It is a flat-bottom plate, and depends on the track spike for holding it in position under the rails.

The longitudinal flange plate was the first form of tie plate to give the necessary adhesion to the tie. There are now many plates on the market of this design, varying in detail only. These plates are rolled with deep, thin flanges on the under side, running in the direction of the plate, and when embedded in the tie, unite so firmly that they become a part of it, and thus prevent the tie abrasion. This form of plate is used very extensively in the Western and Southern states, where soft wood ties are in general use. These plates were long used much too thin and too narrow. The size of a tie plate should be determined by the density of the wood on which the tie plate is to be used, and weight of rolling stock. The plate should be thick enough to resist buckling during the life of the tie at least.

The only cross grain claw plate in successful use is the Goldie claw tie plate. It has a shoulder on upper surface to abut against outer base of rail, and has four ½-in. claws on under side, which are finished with a Goldie spike point, giving sharp cutting edges. These claws enter the tie with a clean cut across the grain, and give not only great adhesion to the tie, but offer enormous resistance to rail spreading. These plates are used on tangents and curves, but more particularly on curves. On curves they have replaced our old, and at one time much valued friend, the rail brace.

In hardwood ties this is the only plate that can be embedded with any degree of satisfaction. Its embedding is accomplished by either driving them home, striking the plate over the claws with the hammer, or allow the traffic to do the work.

In the discussion some thought there was more decay under the plates than elsewhere, while others found no such result. This difference is probably due to the fact that where the plates are not driven into close contact with the face of the tie, water may get beneath them and cause local decay. Mr. Lahey (Chicago Terminal Transfer Ry.) said that where ties were formerly cut out by the rails in three years, they will now last 15 or 18 years when protected with tie-plates. Mr. Cafferty (A., T. & S. F. Ry.) said that he could not maintain track in good condition without tie-plates.

TREATED TIES.—A letter from Mr. G. W. Rhodes (Gen. Supt., Wyo. Dist., C., B. & Q. Ry.) was read stating that 50,000 ties a month are now being treated by the zinc-chloride process. These ties are used mainly in dry districts. The treatment prevents dry-rot, but he doubted if it would be satisfactory in moist districts, and he did not think a subsequent treatment with tannin would be a benefit.

The meeting on the second day of the convention was opened with brief remarks from some of the old members.

SURFACE, LINE AND GAGE.—This report was by Mr. C. Linehan (G. R. I. & Pacific Ry.), and was the first report presented and an abstract is given below:

To maintain perfect surface, line and gage, it is essential, first to have banks sufficiently wide, having a slope of 1½ to 1, and so prepared for ballast as to permit of perfect drainage; shoulder to slope slightly from base of ballast and should be in width at least 7 ft. outside rail. Ties should be as near uniform in width and thickness as possible, spaced equally, and lined on one side of track (preferably the line side). Care should be taken that ties be perfectly square across track, and that all ties be equally and thoroughly tamped outside and 16 ins. inside rail, leaving a space of 22 ins. of center of tie untamped, but which should be thoroughly filled under the ties.

Track when ballasted or given a general surface should be put to perfect surface line and gage, with a shoulder of ballast sufficiently heavy to hold same in line; for first class track, shoulder should be 5 ft. outside rail, 2½ ft. level and 2½ ft. slope; track should be filled inside to the level of base of rail, keeping flange of rail and top of ties clean.

To maintain perfect line, track must be kept in almost a perfect surface, as track cannot be made to stay in line when out of surface. To maintain perfect gage, you must also keep track in perfect surface, as the power and rolling stock have the same influence on gage as on line.

When renewal of ties is being made track should be carefully gaged, all spikes that are not up to the rail snug should be pulled and holes plugged, then spikes redriven in plug to prevent any oscillation, and on curves of 4° or over, where traffic is heavy or a high rate of speed is attained, the Goldie claw tie plate should be used to prevent rail being crowded out by heavy engines.

In the discussion, Mr. Cafferty (A., T. & S. F. Ry.) objected to lining the ties at one side of the track, as with ties of uneven length this leads to uneven bearing in the ballast. Several members thought it would be very troublesome to line ties by the center, but Mr. Cafferty explained that while ties are lined by one side of the track in construction, in maintenance work they are lined by the center of the track.

This precipitated a discussion on length of ties, several members claiming that should be a standard length, and that ties varying from this by 4 or 6 ins. should not be placed in main track. A few members seemed to think that this would be impracticable, but Mr. Jones (C., B. & Q. Ry.) said that his road uses sawed ties and very rarely finds any variation from the standard length. He had had trouble from the mixing of ties of different kinds of wood, and now the tie inspectors use paints of different colors for marking the different kinds of ties, so that they may be kept in separate lots in the track. As to ditches on top of cuts, these cannot always be made within the limits of right-of-way; in such cases he uses a ditch formed in the slope of the cut, and inclined each way from the top of the middle of the cut to the bottom at each end.

IMPROVED TOOLS AND APPLIANCES.—This report was read by Mr. C. B. Teller (C. & E. I. Ry.). It dealt mainly with the screw spike, and the electric spiking and tamping machines recently described in our columns. He also mentioned the method of laying track for steam shovels, which we have illustrated; and referred to the advantages of steam shovels and the Lidgerwood rapid-unloader for such work as filling trestles, track elevation, etc. Mr. Jones suggested that the Elliott frog for yards be included as an improved appliance worthy of attention.

RAIL JOINTS.—A brief report on this subject was presented by Mr. W. E. Emery (C. & N. W. Ry.), an abstract of which is given herewith; the report recommended a support under the joint, but this recommendation was struck out after some discussion:

Some of the essential features of a good joint should be as follows:

(1) Strength and stiffness.

(2) Such shape and form as to be easily and quickly taken off and put on, and not require any special preparation in the way of digging or spacing ties before putting on the joints.

(3) Top edges of bars should be wide enough to give the largest possible bearing surface under the head of the rail.

(4) The greatest thickness and depth possible to fit properly and snugly between the head and base of the rail.

(5) Suitable provision to prevent creeping of the rails.

(6) Having alternate round and oval holes in the bars so that bolts with elongated necks be used.

(7) All nuts should be provided with nut locks.

(8) The joint must allow the expansion and contraction of the rails when the joint has been properly tightened.

(9) Bolts should be put on alternately; that is, each second bolt should have the head outside, and the others inside.

(10) Should have the least number of parts possible, with regard to obtaining strength and stiffness.

Our experience, apart from the ordinary angle-bar or fishplate joint, has been mostly with an angle-bar joint supported with a channelled base-plate of the same length as the angle bars, supported on two ties. This joint was designed by the chief engineer of the Chicago & Northwestern Ry., Mr. E. C. Carter. We do not know of any joint that fills more of the foregoing requirements. There is a very large number of patented joints on the market, some of which have more merit than others, and we would suggest that a committee be appointed to investigate the merits of joints and report at the next convention.

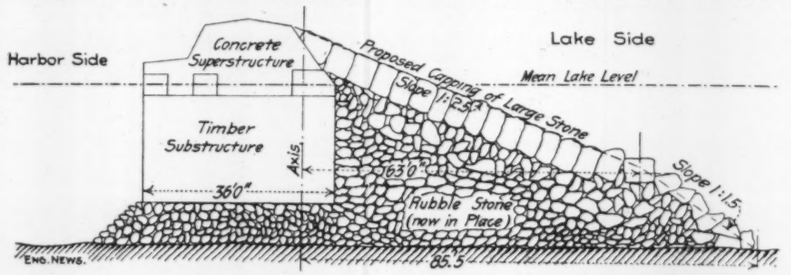
In regard to the prevention of creeping, the member favored bars with flanges wide enough for holes instead of slots for the spikes. To the use of oval holes, Mr. Morrison thought oval holes in bars on the nut side of the would allow too much expansion movement. His suggestion alternate round and oval holes recommended, with bolts having nuts alternately inside and outside the rail.

OFFICERS AND PLACE OF MEETING.—The election of officers resulted as follows: President, C. F. Blue (M. & O. Ry.); Vice-Presidents, J. Single (L. Id. Ry.) and C. B. Teller (C. & E. Ry.); Secretary and Treasurer, C. E. Jones (C. & Q. Ry.), Beardstown, Ill. The next meeting will be held at Niagara Falls, N. Y., in September, 1905.

REINFORCEMENT OF RIPRAP PROTECTION OF THE BUFFALO BREAKWATER.

Most of our readers will recall the extended descriptions of the new breakwater work at Buffalo, N. Y., contributed to this journal by Major T. W. Symons and Mr. Emile Low, and published in 1901 and 1902. It will be remembered that some very remarkable and unprecedented work has been carried out there in the laying of a paving of large stones under water to protect riprap slopes from wave action.

We are informed by Lieut. P. S. Bond, the engineer now in charge, that further work of this sort is to be done to protect the rubble stone filling on the lake side of the timber-crib concrete breakwater, South Harbor section. The accompanying cross-section shows this part of the breakwater as it will appear when the heavy stone paving has been placed.



CROSS-SECTION OF BUFFALO BREAKWATER, SOUTH HARBOR SECTION; TIMBER CRIB AND CONCRETE SUPERSTRUCTURE, SHOWING LARGE STONE PAVING ON RIPRAP SLOPE.

A 42-IN. WOOD STAVE CONDUIT FOR THE WATER SUPPLY OF ATLANTIC CITY, N. J.*

The first wood stave water-works conduit of any length in the eastern part of the United States, so far as we remember, was laid early in the present year at Atlantic City, N. J.. It is 42 ins. in diameter, 9,807 ft. in length, is laid (approximately) on a 0.016 grade and has an estimated minimum carrying capacity of 8,000,000 gallons per day and a maximum capacity of 12,000,000 gallons. The conduit was constructed by the water department of Atlantic City, of which Mr. Kenneth Allen, M. Am. Soc. C. E., is engineer and superintendent. Mr. Henry Goldmark, M. Am. Soc. C. E., of Montreal, was consulting engineer on the preparation of plans and Mr. C. J. Myers, Jun. Am. Soc. E., was assistant engineer of the water department, in direct charge of the work. The work was done by the C. P. Allen General Contracting Co., of Denver, Col., under an agreement which provides for maintenance for two years and for delivering the conduit to the city in good condition at the end of that period.

The conduit replaces an open ditch connecting a storage reservoir with a small reservoir near the Absecon pumping station of the water-works. This ditch lost carrying capacity on account of aquatic growths, and the supply carried by it was endangered both by damage to the banks by

*Based on a paper by Mr. Kenneth Allen, M. Am. Soc. C. E., Engineer and Superintendent Water Department, Atlantic City, N. J., read before the New England Water-Works Association at Holyoke, Mass., Sept. 14, 1904. The paper will be published in full in the Journal of the Association. The paragraph on the wood stave force main proposed in 1900, in place of which steel was finally used, was based on other sources of information.

...boats and the possible failure of the wooden ... used at stream crossings. Another danger ... flooding with salt water by the combined ac... of flood tides and northeast winds backing up ... in the marshes until it overflowed into the ...

...fore proceeding further with a description of ... wood stave conduit a few words may be said ...rding the 30-in. steel force main contracted ... in November, 1900. In that year the water ...missioners, acting on the advice of their engi... Mr. W. C. Hawley, M. Am. Soc. C. E., now ... Wilkinsburg, Pa., and their consulting engi... Mr. Emil Kuichling, M. Am. Soc. C. E., of ...hester, N. Y., proposed a wood stave force ... 27,300 ft. long, across the salt marsh to the ...* The city council insisted on inviting bids ... steel and cast-iron as well as wood stave pipe. ... only bidder for wood pipe was the T. A. ... Co., of Pittsburg, who bid $133,000, but ... also bid $130,000 for steel. Under the bids ... at the same time a cast-iron force main, ... with mineral rubber coating, would have ... $146,684 and a cast-iron pipe with ordinary ... would have cost $129,000. Tar-coating ... not considered advisable, as cast-iron pipe ... in that manner had deteriorated where ... in the marshes. The specifications for the ... pipe called for a protection of mineral rub... and, outside of that, a wrapping of burlap. ... understand from Mr. Allen that the steel pipe, ... far as known, has stood well up to this time, ... nevertheless the arguments in favor of wood ... pipe in the salt marshes, combined with ... comparative estimates of cost, led to the adoption ... that material in the present instance. It may ... noted that the wood stave conduit built this ... is under a very slight head, thus reducing ... the cost of the necessary steel bands. A sheet ... pipe, built at anything like the theoretical ... permissible thinness of plate would have been ... risky indeed, when laid in a salt marsh.

Reverting now to the wood stave conduit laid this year, it may first be noted that the conduit was located, so far as possible, in the bed of the canal.

The specifications permitted the use of California redwood, long leaf yellow pine, southern cypress or Oregon, Washington or Douglas fir. Washington fir, from the Wallace Lumber Co., Startup, Wash., was used. The staves were cut from 2 × 6-in. lumber. They measured 19-16 ins. in thickness, and 5⅝ ins. on the inner surface. The staves received ranged from 9 to 33 ft. in length, 6¼% being under 12 ft. and 25% under 16 ft. long. The minimum length allowed was 10 ft. The ends of the staves were joined by tongues of 1⅛ × 5¼-in. tongues of No. 12 gage iron.

The bands were of mild steel, with pressed threads, and the saddles were of malleable iron. Bands, nuts, washers and saddles were coated in the field with hot mineral rubber. After laying the metal work was painted, where needed, generally with durable metal coating and, where rapidity of drying was important, by P. & B. paint. The bands were spaced 12 ins. c. to c., on straight cylindrical pipe; otherwise, the spacing was 9 ins. c. to c.

Trenching was begun on Feb. 4, and the conduit proper was completed on April 16, 1904. The material encountered was largely sand. The canal was dammed off and pumped out in sections. The pipe gang generally consisted of 1 foreman, 2 men handling material, 2 driving staves, 2 tightening bands, 1 rounding out by hammering inside, 2 back-cinching, 1 (a boy) painting bands, 2 tamping. There were also employed on the work 4 day and 2 night pump men and 35 men for backfilling. At times two pipe-laying gangs were at work.

After testing under pressure and calking leaky places the leakage was reduced to about 78 gallons per min., or only 1 gallon per day per sq. ft. of outside surface of the conduit.

The contract price for the pipe laid, without earthwork, manholes, blow-offs and the like, was $2.25 per lin. ft., and the total cost of the whole work, including inspection, was $30,230, or about $3.10 per lin. ft. Some further cost figures are given in the extracts from Mr. Myer's notes, given below.

*See Eng. News, Oct. 4, Nov. 1 and Nov 29, 1900.

Commenting on the choice of Washington fir, Mr. Allen remarked that both cypress and cedar would doubtless be suitable for wood stave conduits, but the supply of each is too limited. California redwood, he understood, is becoming reduced in available quantity, so it is gradually being forced from competition. Washington or Oregon fir is plentiful and probably will remain so for years, and in spite of a freight charge of $300 per car, "this seems at present the most available lumber for the purpose, as it can be had on short notice and as there is little loss from culling." Southern pine "can be secured in large quantities of sufficiently good quality, by moderate culling, for satisfactory results, and would probably be the most economical in the Southern States."

ADDITIONAL INFORMATION BASED ON NOTES BY MR. C. J. MYERS, JUN. AM. SOC. C. E.

In the computations for the size of the conduit c in Chezy's formula was taken as 110. The conditions for testing the conduit being unusually favorable, this value will probably be checked. In selecting the grade line of the conduit the double aim was to give sufficient head for constant saturation and to avoid as much excavation as possible. The curves were of 24°. Reducers and 24-in. gate valves were used both for economy and so one man could easily handle the valves.

Measurements of the completed conduit show an average vertical diameter of 41.5 ins. and a horizontal diameter of 42.5 ins. Much of the backfilling was done with frozen earth.

Inexperience of the men, but more particularly severe weather, caused the first 26% of the work to cost more than the last 74%. The amount of labor per lineal foot of pipe in hours during these two periods was as follows:

	Backfilling and excavation.		Pipe Construction.	
	Foreman.	Laborers.	Foreman.	Laborers.
Feb. 4 to March 5..	0.28	4.92	0.13	1.05
March 5 to April 16.	0.18	2.91	0.07	0.73

Laborers were paid about 15 cts. per hr. for backfilling and excavation, and about 20 cts. per hr. for pipe construction. Foremen were paid from 25 cts. to $1 per hr., probably averaging 40 cts.

NOTES ON FIREPROOFING CITY BUILDINGS.*

By Perez M. Stewart, M. Am. Soc. T. M.

INTERIOR FIRES.

THE HORIZONTAL FIRE HAZARD.—Large unbroken floor areas tend to increase greatly the spread and intensity of fire, and wherever possible such areas should be subdivided, and substantial brick fire walls provided with double automatic fire-resisting doors wherever openings are necessary.

THE VERTICAL FIRE HAZARD.—All vertical openings, such as stairs, elevators, light and vent shafts, etc., communicate fire readily from one story to another, and where buildings are of any considerable height this feature forms the most serious menace to any building once afire. All such openings should be enclosed in walls of brick or other fire-resistant material, and where necessary to pierce such shafts, the door or window openings should be fitted with the best type of fire-resisting doors or shutters, and wire glass introduced where light is needed.

It has been the custom in New York city for the past ten years to protect in this manner all door and window openings in elevator shafts of manufacturing and loft buildings and stores, as well as many hotels and apartment houses and some of the principal office buildings.

The Baltimore fire brought out with greater clearness than ever the two distinct fire hazards with which every building must reckon. First, the danger of its being destroyed by fire occurring within its own walls; second, the danger of a building becoming ignited from the attack of a fire existing in a neighboring building.

These two hazards are but rather distantly connected. We may have, for example, a building of highly incombustible construction, each floor of which is separated from the other floors in the most effectual manner, and provided with efficient interior means for fighting a fire occurring therein. Given such a building, it is highly probable that, even though each floor contained a considerable amount of inflammable material, a fire occurring on any particular floor could readily be confined therein. There is nothing to prevent, however, such a building as this from taking on fire every story at the same time, by fire contributed to it through its windows from a neighboring building. This is precisely what happened in the Calvert Building in Baltimore. While the Calvert Building did not realize all these conditions, having unenclosed elevators and stairways, and contained more or less wood trim, flooring, etc., still it was an average example of its type, in other words, of the "fireproof office building," which does not burn so long as it is not attacked by fire. It took fire, by the best of evidence, on seven different floors at practically the same moment, and every pound of inflammable material in the building was burned up and the ashes blown out of the windows.

THE EXPOSURE HAZARD.

Probably no other feature of the fire danger is receiving so much attention from fire insurance companies and their engineers as the exposure hazard. The National Board of Fire Underwriters has a working committee of twenty chief officers of prominent companies who have now in progress an investigation of each of the principal cities of the country, looking to a report on this subject and means to be taken for its reduction.

Even after the introduction of wire glass, underwriters generally advocated the use of iron or tin-clad shutters at all wall openings exposed to attack by fire, and notwithstanding their many weaknesses, this preference was held in many quarters until the Baltimore conflagration. The comparative showing made by metal shutters and wire glass, however, has proven a most convincing argument.

In all types of iron or tin clad wood work, especially shutters, in addition to the possible dry rot of the wood through being covered green, or by chemical action set up within, must be expected an almost certain corrosion of the metal. Especially if exposed to the weather, a frequency of painting and a degree of care such as it seldom gets is all that will keep it intact. In this respect wire glass has the advantage in that it can be seen through and any imperfections noted.

The only proper metal for covering wood is copper or bronze. One of the chief drawbacks to the use of metal-covered wood of any kind is the impossibility of inspecting the wood, although, if bought of reliable concerns and the wood inspected occasionally at the factory, good results should be had. In all cases the metal should be painted on the inside with some approved anti-corrosive paint before being drawn on the wood.

SUBSTITUTES FOR WOOD.

A difficult problem is that which concerns some suitable substitute for ordinary wood for interior finish in the best class of buildings. Wood plays so important a part in the floors, windows, doors and trim, however, that anything which proposes to displace it must have many excellent features.

Three general types of substitutes have been brought out and used with varying success:

First—So-called "Fireproof" wood, ordinary wood treated with chemicals, with the result that it will not burn or carry flame to any considerable extent save in the presence of an outside and contributing flame. Its disadvantages are the difficulty of working it with ordinary tools, its variations in quality and the possibility, though not probability, of its deterioration through atmospheric action. It has been used, however, satisfactorily in many important buildings.

Second—Kalamined or metal-covered wood. Is an excellent fire resistant. It is not excessively expensive, and can be easily worked. Architects' details can be carried out readily, and it can be given any finish possible to metal surfaces, and it is used extensively in New York city.

Third—In Alignum and British Uralite we have, however, two incombustible materials.

In his recent report on "Protection of Theaters," Edward Atkinson describes Uralite as follows:

> Uralite is an artificial stone, made in large sheets of about three and one-half by four or by six feet, a little less than one-eighth inch in thickness, slightly flexible, possessing a sufficient tensile strength for its use and resisting a very great crushing stress. It was invented in Russia, named Uralite from the Ural Mountains, whence the asbestos is taken which forms the largest component material. It is made of asbestos, chalk, silicate of soda and carbonate of soda, worked by chemical process under heat and pressure into a homogeneous substance consisting wholly of incombustible materials, flame-proof, heat-resistant at excessive temperatures, water-proof, neither expanding nor contracting under heat or cold, weather-proof and exceedingly effective as a non-heat conductor. It is in extensive use in England, where it is now made as a substitute for slate in roofing, for the construction of bungaloes in England and in India, of barracks for army posts, for the inside finish in very many breweries in places where plastering will not stand, for the inside finish of theaters, hospitals, art galleries, and the like, for the construction of incombustible cars for subway use, and for many other similar purposes. It is on trial at the Brooklyn Navy Yard for naval construction, and a section has been laid down on the Brooklyn Bridge to test its durability on a footway. It is endorsed by British Boards of Fire Underwriters generally and is used extensively by the Admiralty Board and various European municipalities.
>
> This material can be worked with ordinary carpenter's tools without injury to them. It may be polished, marbled, veneered, painted, frescoed, or papered, and may be put on in the simplest manner over the underside of ceilings or on the woodwork of walls. The durability in service for flooring has yet to be determined.
>
> The hard Uralite can now be imported at a cost of less than 7 cts. per sq. ft.

*Extracts from a paper on "The Fire Resistance of Modern High Buildings," read before the International Association of Fire Engineers, at Chattanooga, Tenn., Sept. 13, 1904.

It is hoped that the manufacture of Uralite may soon be established in this country on a large scale.

Alignum is composed of ashes, asbestos fiber, a secret compound and a binder, none of which are in any degree inflammable—in fact, at least 99½% of the material is absolutely inert under all conditions of fire, and the remaining ½% (water) would evaporate.

The material is mixed and molded into slabs by a process which simulates felting, working the fibers of the asbestos out and interlocking them, then slightly dried in the air and finally dried in hydraulic presses with steam-heated platens having a temperature in drying of about 300° and a pressure of 200 lbs. per sq. in.

After thoroughly drying the slabs are removed from the press and permitted to cool off and at the same time to season before use. The slabs can be molded to any size or form, but commercially it is found desirable to make a so-called lumber 4 ft. wide and 10 ft. long, ¾-in. in thickness, from which any desired thickness can be worked up. For door panels and similar large slabs a certain amount of wire is worked into the slab in the process of molding, which adds very materially to the ability of the material to resist sudden blows. The material is worked in a planing mill just as wood would be worked. The pieces can be glued together, using a special mixture of which glue forms a relatively small part, the setting being done under pressure, and it can be filled and finished so as to imitate any natural wood in a manner to defy detection, or painted, varnished, enameled or treated in any other way which may be desired. About the only drawback lies in its being somewhat brittle and as a consequence it is difficult to reproduce delicate moldings or very small members. In full slabs, or even in pieces 12 ins. wide, it can be handled like lumber and possesses considerable strength. Reinforced with metal, it is for equivalent thickness about as strong as spruce. It can be sawed and nailed into readily.

Alignum doors are made 1⅛ ins. in thickness; for a 3 × 7-ft. door a slab 3 ft. by 7 ft., ¾-in. thick, but surfaced on both sides so as to obtain a resulting thickness of ½-in. is used as a base, and on it the stiles, raised panels, etc., are planted, the stiles being ⅛-in. thick on each side. In this way a door is obtained that is positively proof against warping and is impervious to fire. It is the practice in all Alignum doors which have glass panels to use only wire glass and all sash in partitions are similarly treated.

An example of its use is in a new 18-story hotel building on the southwest corner of 55th St. and Fifth Ave., New York city. In this building the floor construction is of porous terra-cotta blocks, the bottoms of which form the ceiling. The upper side is filled with 4 ins. of cinders grouted with cement, surfaced with 2 ins. of good cinder concrete and finished with a granolithic surfacing of about ½-in. The partition blocks in all cases rest directly on the arches; the door bucks are of fireproofed wood, completely surrounded on three sides with Alignum and butting against the partition blocks on the remaining side; the door frames, jambs, trim and the doors themselves are of Alignum, much of it with wire lath imbedded; the door saddles are of marble; the trimming of the rooms is effected with a low base of Alignum, with cement moldings, paneling the walls; the window trim is of Alignum, the casings, panel backs, jambs and soffits are of Alignum; to secure the carpets, narrow strips of wood are imbedded in cement. As a consequence, if materials were brought into a room for the purpose of making a fire, the only exposed wood which would be liable to attack would be the three-quarter inch wide tack strip. It may, therefore, be said that it would be impossible to maintain a fire or even start a fire in any room without the furniture. In the furnishing, the endeavor will be made to minimize the amount of inflammable material; the precise method which will be employed has not been decided upon, but it is quite evident that the hangings and carpets can be treated so as to be at least very slow-burning, and the woodwork reduced to a bureau or dressing case and chairs, which can also be treated. The same plan is followed throughout all rooms and corridors. Plumbing and steam pipes are carried in chases, which are cut off by plaster and wire lath at every floor, so that they are non-continuous; the electric wires are all in iron conduits, and there is not in the entire building a place where the electric wiring comes anywhere near wood—in fact, there is no wood for it to come near (with the exception of the tack strips and door bucks); all panel boxes are full, of iron and marble with Alignum covers. Every door in the building is of fireproof construction; none of the stairways in the building run continuously the full height of the building, but in all cases there are offsets from the third floor down, protected practically by double fireproof doors. The disposition of doors and stairways makes it practicable to flood any section to the height of the window sills, were it desired, and the only way by which the floors could be drained would be by opening the doors so as to permit the water to run down the stairways.

It is certain that the amount of wood used in building will be reduced rapidly, its place being taken by some other thoroughly incombustible substitutes.

INCOMBUSTIBLE FURNISHINGS.

Considerable study is now being given to the production of more or less incombustible interior furnishing fabrics of all kinds may be rendered largely fire-resistant by being dipped in some of the combinations of soda or ammonia. The result obtained is not permanent, wearing off at the end of a few years, although the Blenio Process used for theater scenery in New York seems to be giving good satisfaction. The processes are very inexpensive, however, so this objection is not vital, while the increased protection, though by no means ideal, fully justifies the expenditure, particularly in hotels, theaters and other buildings where people congregate in numbers.

Probably the best solution to the problem of fire-retardant furniture is found in metal-covered wood. This is now made by several concerns to fill all the demands of office and other mercantile equipments—desks, chairs, tables, book cases, filing cases, etc. Examples of this equipment have been subjected to very severe fire tests and have demonstrated everything claimed for them by the makers. While comparatively expensive, it is likely in view of its efficiency, that metal-covered furniture will come into extensive use. It gave a good account of itself in Baltimore, and is being used extensively in the Carnegie Libraries.

The use of metal ceilings is to be thoroughly condemned.* They are usually put on to hide broken and often unsafe plastering, and in the event of fire the nails with which they are fastened are apt to pull out, dropping the metal sheets. Furthermore, the open spaces back of metal ceilings, in new and old work, offer dangerous draft openings for fire to follow on account of lack of adequate fire stops between beams.

THE TERM "FIREPROOF."

The word "fireproof" is open to no little criticism. As a strictly descriptive term it is misleading for the reason that we have no absolutely fireproof materials, and it is generally used to describe either material or construction which has a greater or less ability to withstand the effect of excessive heat. Its use has generated in the public mind a degree of false confidence not borne out by actual test. This matter was brought up last year at the convention of the International Fire Prevention Congress held in London, England, and the term decided upon at that time was "fire-resisting" rather than "fireproof." The matter was discussed at the 1904 meeting of the National Fire Protection Association, and the sentiment expressed that this meeting was in favor of the term "fire resistive."

Since, however, the term "fireproof" is in such common usage, it may with propriety be used to describe those materials which give respectively the highest degree of fire resistance of which the present stage of the art admits.

As expressed recently by Rudolph P. Miller, Chief Engineer of the New York Bureau of Buildings, "Fireproof" is a very good word to describe the *best* materials for resisting the effect of heat, but it should not be used indiscriminately. A certain door, for example, may have the highest degree of fire resistance of any door possible to make, yet in point of resistance it is in no wise to be compared to a heavy brick wall. Fireproof is a flexible term, yet it should never be applied to any type of material not the best of its kind.

It is probable that some term signifying a high resistance to fire will some day be generally substituted for the much-abused "fireproof."

Much remains to be learned of fire-resisting construction, yet the experiments of the past give us every encouragement. Even to-day we can build a structure which will be to all intents immune against fire from within or without.

We are still in an experimental stage, however. We already know what we can do, though the best means for insuring this result may yet be undetermined. The most serious danger lies in inferior workmanship, and substandard materials. Like most other problems, it is a matter of judgment and of final economy.

*However, the following case is worth note: In a recent fire in a lodging-house containing a saloon on the ground floor, the fire, which started in the saloon, was confined to that story by the metal ceiling which had been put on for decorative purposes. It seems reasonable to hold that metal ceilings preperly applied will offer *some* degree of fire-protection.—Ed.

A SO-CALLED RUSTING TANK FOR PRODUCING A COAGULANT FOR WATER PURIFICATION.

A so-called rusting tank has been added to the water purification plant of Antwerp, Belgium, for the production of red ferric oxide for use as a coagulant. The water supply of Antwerp is drawn from the River Nethe, about eleven miles from Antwerp. The river is subject to tidal influences, so the supply is pumped from the river at low tide and stored in reservoirs, which afford about twelve hours sedimentation. Originally the water was passed through spongy iron filters and then through slow sand filters, at a lower level. Owing to mechanical difficulties in operation the spongy iron filters were replaced by Anderson revolving purifiers, of which there are now five in use. Each of these purifiers is an iron cylinder, 5 ft. in diameter and 15 ft. long, revolving on its axis at a speed of about [illegible] per min. Particles of iron placed in the cylinders are kept falling through the water by the rotary motion of the cylinders. In this way ferrous oxide is formed. The water thus treated is passed through an open channel having a false bottom. Air from a blower is forced through holes in this false bottom, thus aerating the water and changing the ferrous oxide to ferric oxide, which acts as a coagulant on the water passing to the slow sand filters. With a normal condition of water the five purifiers can treat 3,600,000 U. S. gallons of water in 24 hours.

The quality of the water varies so that at times the dissolved iron does not precipitate completely before passing through the filters, making it necessary to throw the revolving purifiers out of use.

The foregoing statements are based on a paper by Mr. Easton Devonshire, Assoc. M. Inst. C. E., prepared for the use of the members of the British Association of Water-Works Engineers on their visit to Belgium in May, 1904. Mr. Devonshire's description of the so-called rusting tank is as follows:

> It is found that when the red ferric oxide can be produced by or introduced into the water in sufficient quantities a very marked improvement takes place, both in its appearance and chemical composition, and with this view the experiment is being made of passing the water through coarse steel turnings exposed to a powerful jet of air, by which means rust is rapidly formed and is carried forward to the sand filters by the flow of water.
>
> Encouraged by the excellent results of experiments with this rusting process on a small scale, the company has constructed a tank through which the whole of the water flowing to the sand filters can be directed. This tank, which holds 22,000 gallons (26,400 U. S. gallons) of water, is constructed of concrete, in which is embedded a framework of steel joists and angle irons supporting a network of expanded metal. The tank is divided into partitions by means of light baffle walls, arranged so as to cause the flow of water to pass alternately upwards and downwards through the rusting metal with which it is intended to fill the successive divisions. The experiments are still in their infancy, and further experience must be gained before determining what is the most efficient method of applying the "rusting process" on the large scale.

The water thus treated passes through the aerating channel already described and then to the slow sand filters.

Mr. Adolph Kemna has local charge of the water-works of Antwerp, which are owned by the Antwerp Water-Works Co., a British corporation.

AN ELECTRIC TRAMWAY TO THE TOP OF MONT Blanc has been authorized by a decree of Aug. 3, 1904, of the Council-General of Haute Savoie, says "Le Genie Civil." The first section, which is to be built at once, leads from Fayet, in Upper Savoy, to L'Aiguille du Gouter, reaching an altitude of 12,595 ft. The total distance from Fayet to Mont Blanc is 7.5 miles horizontally, and the final altitude to be reached is 15,777 ft. above sea level. This is a greater elevation than the summit of the Jungfrau, which is 13,664 ft; and just exceeds the 15,468 ft. of the Pike's Peak railway. The Mont Blanc line is to commence at an elevation of 1,902 ft. above the sea, and the development of the line requires a length of 11.4 miles to L'Aiguille du Gouter, or 13.95 miles to the summit of Mont Blanc. Up to the Tete-Rousse, at an elevation of 9,594 ft., the line will be on the surface, but beyond this point the line must be protected against avalanches and falls of rock by tunnelling into the sides of the mountain. But this tunnel will be nearly always close to the side of the mountain and constitute an open gallery for a total length of about 7,314 ft. The maximum gradient is to be 25%, and the maximum curvature 50 m., or 164 ft. The rack-rail will be of the Straub type, the same as used on the Jungfrau Ry., and the line would be operated by an electric locomotive weighing 14 tons. Each train is to carry 30 passengers in two carriages, the total load being 30 tons, including the locomotive. The estimated cost of the line is $2,000,000.

A RECORD IN OVERLAND WIRELESS TELEGRAPHY was made on Sept. 10, 1904, by the De Forest stations installed at St. Louis, Mo., and Chicago, Ill. The St. Louis station is on the World's Fair grounds, and the Chicago station is on the north side, north of the business district, so that many tall city buildings lay between the stations. On the date mentioned the St. Louis station transmitted complete messages to Chicago, about 300 miles overland. A few days before the same station had transmitted to Springfield, Ill., which broke the overland record, but this performance was considerably surpassed by the Chicago transmission. The De Forest system installed for the London "Times" at Wei-hai-wei, China, and on the dispatch steamer "Haimun," has during the early period of the Japan-Russia war sent frequent and perfectly complete messages from Chemulpo, Corea, to Wei-hai-wei, 275 miles. This stretch was mainly across water, but also traversed a number of islands.

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According to Coroner Jackson, of New York City, no less than 30 persons have been killed in elevator accidents in New York City since Jan. 1 of the present year, while a very much larger number have received more or less serious injuries. Such a casualty record ought to command attention, and should form the basis for some public action to remedy the present situation. Mechanical ingenuity has made it possible to instal elevators in which accidents from almost every possible source are guarded against; but there is a long gap between the best the engineer can furnish and the best the public is willing to pay for. A large proportion of the elevators in use in factories and warehouses are not equipped with safety stops at all, and on the elevators where safety stops are applied, many of the safeties are inoperative because of defective design or lack of care in maintenance and adjustment.

The fact appears to be that familiarity in the use of elevators has bred contempt. The caution which everyone exercised when buildings first began to extend above five or six stories in height and elevator speeds were first increased above old standards has disappeared. The lesson of recent accidents is that greater care is needed in the design, installation and maintenance of elevators. The responsibility lies with owners of buildings to see that such care is given, and where this responsibility is unheeded and accident occurs, the penalty is likely to be visited in the form of suits for heavy damages.

There always will be, however, a certain number of penurious owners, who will run any amount of risk to save a little expenditure. Again, as we pointed out some time ago in discussing the causes of building failures in New York City, the title to many buildings is vested in a speculative builder or corporation, while the value is nearly covered by mortgages. Elevators in such buildings are not likely to be installed or maintained with any other consideration than saving of expense. For the better protection of the public, therefore, Superintendent Isaac A. Hopper, of the Department of Buildings, has drafted an amendment to the Building Code, for submission to the Board of Aldermen. The present clause in the Building Code relating to elevators would be amended to read as follows:

> The Superintendent of Buildings shall cause an inspection of elevators carrying passengers or employees to be made at least once every three months, and shall make regulations for the inspection, installation, alteration and operation of such elevators, and shall also make regulations for the inspection, installation, alteration and operation of freight elevators, with a view to safety; and shall also prescribe suitable qualifications for persons who are placed in charge of the running of passenger or freight elevators. The regulations shall require any repairs found necessary to any such passenger or employees' elevator to be made without delay by the owner or lessee. In case defects are found to exist which endanger life or limb by the continued use of such elevator, then, upon notice from the Superintendent of Buildings, the use of such elevator shall cease, and it shall not again be used until a certificate shall be first obtained from said superintendent that such elevator has been made safe. No person shall employ or permit any person to be in charge of running any passenger or freight elevator who does not possess the qualifications prescribed therefor. No person shall run any passenger or freight elevator in the city of New York unless he shall first register at the office of the Superintendent of Buildings his name and residence, and also the location of the building in which he is running said passenger or freight elevator, and shall first receive from the Superintendent of Buildings a certificate as to his competency.
>
> Every freight elevator or lift shall have a notice posted conspicuously thereon as follows: "Persons riding on this elevator do so at their own risk."

It will be noticed that this would empower the Building Department to require the alteration of existing elevators found to be unsafe, and would give it authority over elevators used to carry freight and employees, as well as the regular passenger elevators. It would also establish a system of registry for elevator operators.

An argument for water filtration which is new in this country, at least, is presented at the conclusion of a paper on the general subject of deposits in water conduits, abstracted elsewhere in this issue. As may be seen from the abstract, the paper includes an interesting description of black, slimy deposits in water conduits, believed to be due to iron-forming or secreting organisms. It has been found, in several cases, that slow sand filtration will prevent the formation of such slime. The slime, it hardly need be said, is objectionable on account of its effect in diminishing the carrying capacity of conduits.

In the presidential address at the recent annual meeting of the British Association for the Advancement of Science, Hon. Chas. A. Parsons, the steam turbine inventor, propounded a novel scheme for exploring the crust of the earth. He pointed out that our knowledge of the character of the earth's crust is really based on very meager data. The greatest distance to which man has penetrated toward the interior of the earth, either by mine shafts or by deep borings, is little over a mile, and our only knowledge of what lies deeper is based on study of the strata upturned in past geologic ages, and on observations of volcanoes.

To explore the earth's crust to a much lower level, Mr. Parsons suggested that a shaft be sunk to a great depth. At intervals of half a mile or so stages would be constructed to avoid the well-known difficulties in hoisting directly from great depths and the whole machinery would of course be driven by electric power. By selecting a site where water bearing strata would not be penetrated and providing a huge brine circulating system to cool the shaft at the bottom, Mr. Parsons believed it to be possible to sink a shaft to a depth as great as 12 miles. The work, however, would occupy no less than 85 years, and the cost he set at $25,000,000. Naturally private capital would not be attracted by such an enterprise, but Mr. Parsons suggested that some national government might undertake it as a contribution to human knowledge, which he deemed might easily far exceed in value anything that has resulted from the many millions spent on explorations in the Arctic seas.

It need hardly be said that Mr. Parsons' proposal is interesting at present only as a curiosity of the imagination, but he is undoubtedly correct in his statement that greater knowledge of the earth's crust is desirable.

As a practical matter, knowledge of the nature of the earth's crust at depths of a mile or less, would appear likely to be of more direct value to the race than investigations to find what may exist at depths out of reach for any commercial purpose. At present such investigations of the earth's crust as have been made in deep well borings have very largely gone unrecorded, and the knowledge that might have been thus gained has been lost. To remedy this defect in future the U. S. Geological Survey has just perfected plans for the systematic collection and preservation of records of deep well borings, and will publish annually a record of such borings made during the year. The Survey will furnish to any well driller who will agree to save samples of borings, pocket memorandum books for keeping a log of the borings and canvas bags in which samples of each stratum penetrated can be preserved and forwarded to the Survey at Washington free of postage.

Such a systematic record of well borings should become as the years go on of the greatest value to geological science and the cases are not infrequent where it will be a most useful aid to engineers.

Many specifications contain a clause prohibiting the use of intoxicating liquors, but a clause prohibiting the use of "cuss words" is certainly a novelty. Such a clause, however, is said to have been inserted in a specification governing the building of a church now nearing completion. No man, while at work, was permitted to swear, use indecent language or drink; and it was seriously considered whether the use of tobacco should not be prohibited also. It is probable that no contractor would object to such a clause, and there is everything in its favor, except the difficulty of enforcement. The use of tobacco during working hours is, in fact, prohibited by many managers of men, and with good reason; for frequent stoppages to light pipes are certainly not conducive to effective labor. There is an even better reason for prohibiting the use of liquors entirely, yet it is no uncommon thing in cities to see the "water boy" converted into a beer boy. This practice, however, is confined to building construction, and is seldom seen on engineering work.

A gang of swearing men is usually an inefficient gang, not only because they are expending energy uselessly, but because they are made more quarrelsome by the exchange of oaths.

What would be thought of an army officer who would permit the men under him to drink, smoke and swear in the ranks? Yet the successful manager of men on a contract should be quite as much of a disciplinarian, for without prompt and silent obedience to orders, no work can be handled expeditiously. Aside from questions of morality, it pays to prohibit drinking, smoking and swearing while at work.

A REVOLUTIONARY IMPROVEMENT IN CAR TRUCK CONSTRUCTION.

Some twenty years ago, the late A. M. Wellington, in his treatise on Railway Location, published the first correct and lucid discussion of the resistance of railway vehicles in rounding curves. Since that publication nothing of importance, so far as we are aware, has appeared on this subject until the paper of Mr. Gustav Lindenthal, which is printed in our current issue. Mr. Lindenthal's analysis in general follows closely that of Wellington, although as would naturally be the case in a paper before a technical society, it is given in less detail.

Mr. Lindenthal, however, undertakes the investigation of one element in curve resistance which was not touched upon by Wellington, viz.: the resistance to the swiveling of the truck due to the friction of center plate and side bearings.

Whenever a railway car passes from a tangent to a curve, the trucks have to turn to an angle with the car body, varying with the sharpness of the curve and with the length of the car body. When the car passes off the curve onto the tangent, the trucks have to be turned back, the guiding of the truck in each case being accomplished by the flange of the front wheel of the truck on the outer side of the curve.

It has been generally assumed by engineers that when once the truck was set for the curve, the frictional resistance of the truck to swiveling

would not cause further pressure of the flange against the rail. Wellington, in his discussion, ignored this element of curve resistance entirely. Mr. Lindenthal claims, however, that by reason of the elasticity of the truck frame the flange will be pressed against the rail for a considerable distance on the curve, and also for some distance on the tangent after passing the curve. Consequently he holds that the frictional resistance of the truck to swiveling operates to increase train resistance, rail wear, and flange wear in rounding curves.

There is not lacking practical experience in support of this position. Trains on roads with much curvature have been found to haul much more easily when the center plates were regularly oiled. The fact that rail wear takes place from wheel flange action not only on curves, but for some distance on the tangents at each end is well known to trackmen. This goes to show, of course, that the resistance of the truck to swiveling, and the elasticity of the truck frame, tends to keep the flange against the rail after the point of curvature is passed, as claimed by Mr. Lindenthal.

There is probably no more mechanically absurd construction in the whole railway field than the method now in universal use of supporting a car body on its trucks. For the benefit of those unfamiliar with car construction we will endeavor to explain it in simple terms: When a car is standing still on a level track, the whole weight of the body is *supposed* to rest on two center plates of 7 to 12 ins. diameter, which rest on corresponding center plates on the trucks. Of course such a narrow base for a car body some 10 ft. in width is highly unstable, so it is necessary to supplement these center bearings by side bearings or contact plates located on the truck bolster and body bolster, respectively, about 2½ ft. on each side of the car center.

It will be readily seen that the greater the proportion of the weight carried on the side bearings, the greater the resistance of the truck to swiveling. The car designer therefore tries to keep the side bearings clear when the car is fully loaded and standing on a level track; but even though he accomplishes this when the car is new, after it has run a short time the body and truck bolsters take a permanent set, the center plates wear down and crush into the wooden bolsters and the car runs all the time with a large proportion of its weight on the side bearings. If the designer tries to remedy this by giving more clearance between side bearings when the car is new, he finds that the car lurches badly at the entrance of curves, as its inertia throws it over on the side bearings. Besides this, when a car is so made as to actually leave the side bearings clear, every time it tips, so as to bear on one or the other, as it must continually do in service, the center plates bear on one side only. With modern large capacity cars the result is the breaking of cast-iron center plates and the bending of steel plates, or rapid wear in case either survive.

Cars are built with this mechanically absurd construction solely because they always have been built that way and inertia has prevented anyone from finding and adopting a better way. It is true that ball-bearing and roller-bearing center plates and side bearings have been invented in considerable numbers and have been used to some extent; but none of the devices of this class thus far produced have been adapted to the rough conditions and rough workmanship of railway cars.

Mr. Lindenthal now comes forward with a radically new solution of this long unsolved problem. He abolishes the center bearing entirely and supports the entire weight of the car on the side bearings. These he makes to turn with almost total absence of friction by making them ball-bearings, and of a diameter proportioned to the work they have to do—spheres 26 ins. in diameter. The center bolt is retained and keeps the car body in position on the truck, but there is no center plate around it to carry load as in ordinary car construction. Of course, as the spherical side bearings only roll a few degrees each way, there is no need of actual complete spheres. Cylinders with spherical ends serve the same purpose, and by making them in two parts and telescopic they answer also the purpose of spring cases, and the springs are enclosed and protected from dust, rain, ice, salt water drippings, etc., as they are not in any existing form of car truck. The much discussed problem of making truck bolsters and body bolsters strong enough to carry their load to the center plate without undue deflection or inadmissible depth is at once and finally solved.

There are other features of mechanical excellence in this design of Mr. Lindenthal's which space does not permit us to discuss; but the one which deserves most attention and the one to which his discussion of curve resistance leads is the elimination of the frictional resistance to swiveling. Not alone to reduce train resistance and wear of wheel flanges and rails is this worthy of the attention of the railway manager; but on account of the matter of safety.

We have gone on increasing the capacity of cars from the ten tons of thirty years ago to fifty and sixty tons at the present day. Every other dimension of the car and the track has been changed time and again to correspond to increased loading and increased strains, but the wheel flange remains of the same thickness. This little rim of iron, on the integrity of which the safety of every foot of travel by rail depends, cannot be increased in thickness for reasons well known to engineers. At least, then, we will do well to reduce the stress upon it so far as possible when the way in which this may be done is pointed out.

SOME RECENT SEWER SPECIFICATIONS.

The usual methods of supporting sewer pipes in a trench having a soft bottom are described in text books, but the following method, taken from a recent specification, appears not to have been described:

> When the bottom of the trench is so soft as to endanger the settling of the pipes they will be supported by saddle piles of inch boards driven firmly into the ground with header and maul, using two piles to each length of pipe. Saddle piles shall also be used where the ground is naturally firm, but is soft at the time the pipes are being laid.

In this same specification is another clause not commonly seen, as follows:

> When the pipelaying is stopped for the night, or is stopped by storms or other causes, care shall be taken that the ends of the pipes are closed water-tight with turned wooden plugs, not less than 18 ins. long, made of white pine.

Specification clauses providing for possible changes of grade in sewer construction vary considerably, as quotations given from time to time in the columns of this journal have indicated. The following clause is rather out of the ordinary, and possesses some merits:

> The contractor will receive no extra allowance for excavation on the piling system greater than 14 ft. in depth where such is shown on the profiles. For excavation greater than 14 ft. in depth, not shown on the profiles but authorized by the engineer, the contractor will be paid for the extra earth excavated and backfilled at the rate of $1 per cu. yd. upon the estimates of the engineer based upon the authorized cross-section, the width of such cross-section to be taken at 5½ ft.

The author of this clause appears to have fallen into a not uncommon error, for, while he evidently had in mind earth excavation when he fixed the $1 per cu. yd. for extra work; as it reads, the clause would include extra rock excavation. It is true that there is a rock clause in the specification, but it might be held to apply only to rock shown on the plans and in the bidding sheet. The rock clause is in part as follows:

> All solid rock requiring blasting for its removal will be paid for as rock excavation. The width of the excavation in rock shall not be less than 2½ ft. at the bottom of the trench, and payment will be made for that width with batter of 1 ft. in 10 on each side to the surface of the rock.

It is noteworthy that this clause does not provide for trenches in rock where large sized pipe or brick sewers are to be laid. Undoubtedly the author of the clause did not contemplate laying sewers of such size as to necessitate a trench in rock wider than 2½ ft. at the bottom. Still we note that in the first clause quoted, provision is made for a trench 5½ ft. wide, presumably in earth, although not so stated.

The main criticism of these two clauses is that they are not consistent, but this is a condition by no means uncommon in specifications. It is possible to draw a specification in which each [illegible] by itself is perfectly clear and satisfactory, [illegible] which mutual contradictions lead to an ambi[illegible] that is fatal to the specifications as a whol[illegible]

A very carefully written specification [illegible] sewerage system is at hand. The author ha[illegible] dently used care in the wording of each [illegible] with a view to making perfectly clear t[illegible] contractor what he must do and how he w[illegible] paid for his work. The clause relating to me[illegible] ment of mortar and concrete is, in part, as follows:

> In the preparation of mortar and concrete, the ingredients shall be proportioned by volume and measured and mixed as hereinafter specified. One barrel of Rosendale cement of 300 lbs. net weight, or one barrel of Portland cement of 380 lbs. net weight, shall be taken as 3.6 cu. ft. in volume. Sand, broken stone and gravel shall be more thoroughly compacted in measuring than by shoveling into the measuring box or barrel.

This clause is perfectly clear. It is a question, however, whether it would not be better to specify that 380 lbs. of Portland cement shall be considered as being 3.8 cu. ft., that is 100 lbs. per cu. ft. Such a measure is easily remembered, and it corresponds more closely with the ratios commonly used in laboratory tests, especially where the parts are proportioned by weight.

In this same specification for concrete there are two requirements that seem to be unnecessary. First, it is specified that "broken stone must pass in any direction" through a 2-in. ring; and, second, that concrete must be mixed with "clean water." Stone that will pass in any direction through a 2-in. ring must be screened through circular openings of about 1½ ins., and this means unreasonably fine crushing for most classes of concrete work. Fine crushing decreases the output of a crusher and increases the cost of the broken stone, hence there is an economic objection to such a requirement. In view of the increasing use of rubble concrete, it seems unnecessary to limit the size of the crushed stone at all, except where concrete walls are very thin, or where reinforcement bars are used, or where some other special condition operates against coarse crushing.

As for the "clean water," we infer that this requirement is an inheritance from early writers of specifications, who, for the most part, insisted upon "the very best" as a matter of precaution. So little silt, by percentage, is carried in suspension in even the most roily river water that mortar can scarcely suffer by its use—indeed, recent experiments indicate an actual increase in strength resulting from the use of dirty sands. While ordinarily the requirement of "clean water" adds nothing to the cost of concrete, there are places where it would. Concrete specifications are burdened with enough words as best, hence the desirability of cutting out every word that is superfluous.

The following clause from a recently drawn sewer specification is an example of the tendency on the part of engineers to usurp the functions of contractors:

> The engineer will indicate the points at which work may be begun. He will have the power to concentrate the work in particular places, or to scatter it over different parts at will.

There is a tone about such a clause as this that in itself is sufficient to prevent a shrewd contractor from bidding ordinary prices, unless he has had experience enough with the engineer to know how little or how much the clause means. If a given force of men is crowded into a short section of excavation, their average efficiency may be reduced; and if the force is widely "scattered at will," the efficiency will likewise fall off due to the greater difficulty of supervision. Certain engineers, working under such a clause as the one quoted, might actually help an ignorant contractor by insisting upon proper methods of attacking the work in hand. But many engineers would be likely to know less about the proper methods of attack and management than the contractor who has the best spur in the world—his pocketbook—to urge him to use his wits. Aside from the question of which knows best the most advantageous way to attack and handle the work, there is the matter of authority and its influence upon the workmen. For the preservation of discipline, it is absolutely

essential that workmen be accountable directly to one man, and one man only. When the foreman of a gang of men is suddenly ordered by the engineer, or by the contractor himself, to stop doing what he has started to do, and is treated in a manner that indicates lack of confidence in his judgment, that foreman immediately "goes down several pegs" in the eyes of the men under him. The loss of respect for his authority is certain to result in decreased efficiency of his gang of men. Contractors, as a rule, know this, and give their orders to their foremen quietly and in such a way as not to degrade the foreman in the eyes of the men. An engineer who attempts to usurp the functions of a contractor usually acts quite differently. He gives his orders to the foreman, perhaps without consulting the contractor, and does it in such a way that every man may know that the engineer "is it." This statement holds particularly true of young engineers and inspectors who feel a commendable pride in being in charge of work, but do not appreciate that the contractor had best be left in charge of the men. Wherever one sees a gang of men and their foreman walking hither and thither at the beck of an inspector, he may set it down that he is looking upon an inefficient gang, and timing their work will seldom fail to confirm his guess.

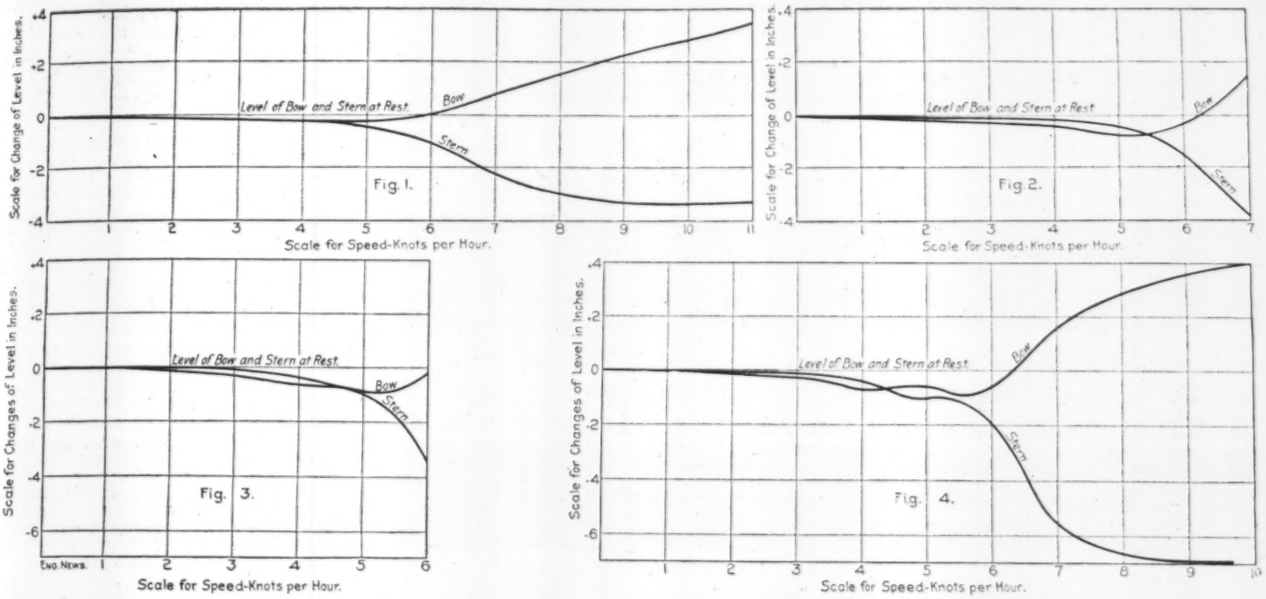
LETTERS TO THE EDITOR.

Experiments with Ship Models on the Change of Draft of Vessels Due to Speed.

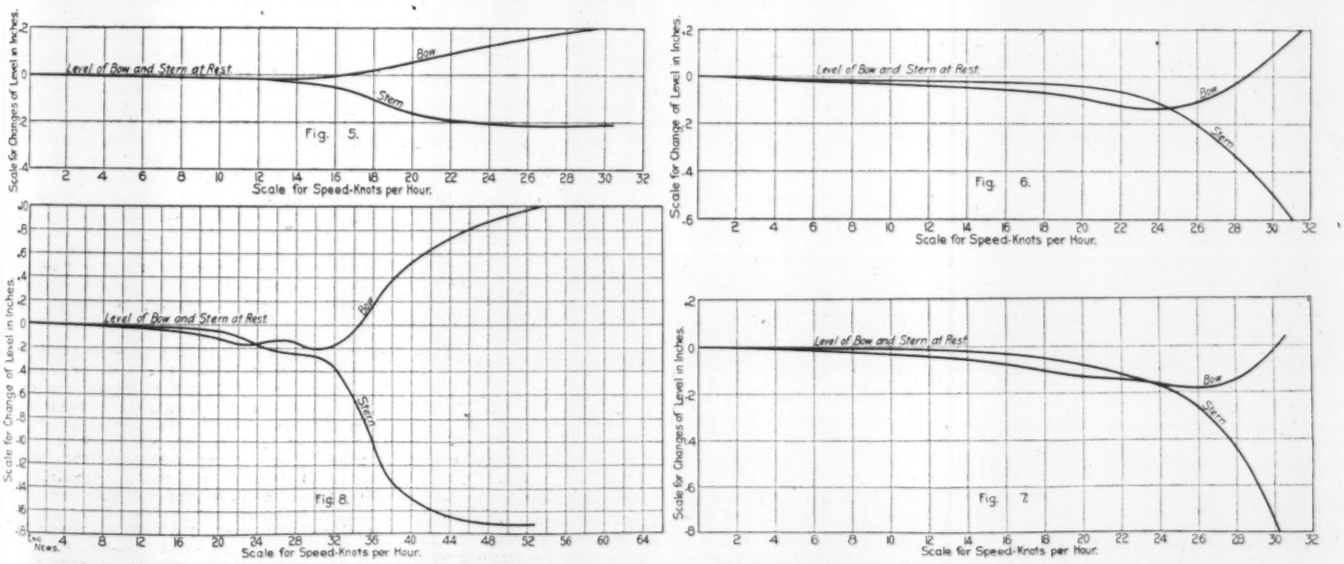
Sir: In your number for Aug. 4, 1904, the editorial comment upon the very valuable and interesting communication by Mr. Henry N. Babcock, relative to the change of draft of ships under way, rather intimates the necessity for further evidence before accepting without reserve Mr. Babcock's results. Your doubting attitude reminds me of an occurrence of ten years ago. During the full speed trial in the open sea of a new battleship an attempt was made by rather crude methods to ascertain changes of level and trim while under way. The observations were evidently in error and the attempt was a failure. One thing which went far to discredit the results was the fact that the observations showed the bow to settle more than the stern. This was regarded as unnatural. One of the first models tried in the Experimental Model Basin some five years later represented this battleship. Observations of change of trim and level showed that at a speed corresponding to the trial speed of the full sized ship the bow of the model settled more than the stern. Since then hundreds of experiments have been made at the Model Basin during which the changes of level of bow and stern of 20-ft. models at various speeds were accurately determined. The conditions of trial corresponded to the ship in deep water—not less than ten times her draft—so the results are not directly comparable with Mr. Babcock's experiments, but they enable the behavior of a ship in deep water to be predicated with great accuracy.

The phenomenon is linear and follows the well known law of similitude. That is to say, if the linear dimensions of the ship are n times those of the model, the change of level of a point on the ship, at a speed $\sqrt{n}$ times the speed of the model, will be n times as great as that of the corresponding point of the model at the speed of the model.

Figs. 1, 2, 3 and 4 show actual curves of change of level of bow and stern of 20-ft. models representing four different classes of vessels. These figures are typical. The general nature of the phenomena can be readily expressed in words. As the speed of a 20-ft. model increases from zero, both bow and stern settle at first, and, in the majority of cases, the bow settles more than the stern at the lower speeds—under three knots. As the speed increases the stern settles faster and the bow stops settling until at a speed a little above five knots the bow begins rather suddenly to rise and the stern to settle very rapidly. The bow will reach its level at rest for a speed in the vicinity of six knots and continue to rise as speed increases, though rather slowly at speeds above eight knots. At about nine knots the stern has reached its greatest settlement.



FIGS. 1, 2, 3, 4. CURVES SHOWING CHANGES OF DRAFT OF 20-FT. MODELS AS DETERMINED IN THE U. S. EXPERIMENTAL TANK, WASHINGTON, ILL.



FIGS. 5, 6, 7, 8. CURVES SHOWING CHANGES OF DRAFT OF ACTUAL VESSELS CORRESPONDING TO THE MODELS OF FIGS. 1 TO 4, COMPUTED FROM CURVES FOUND FOR THE MODELS.

The model speeds of Figs. 1, 2, 3 and 4 extend to speeds far in excess of those corresponding to the actual speeds of full sized ships. Figs. 5, 6, 7 and 8 show the curves of change of level for the full sized ships as deduced from the model curves. These curves show with sufficient accuracy what would happen in deep water with

the ships towed. The effect of the engines would be to increase the stern settlement, but it would be very slight, indeed. In shallow water the curves of Figs. 5, 6, 7 and 8 would be materially modified.

The primary result of shoaling the water would probably be to increase settlement at the low speeds, particularly of the stern, and to change the critical speed at which the bow begins to rise and the stern to settle rapidly. Mr. Babcock's observations show clearly the tendencies. It would be interesting to supplement them by experiments with models representing some of his full sized ships in water of depth corresponding to that of the channel into New York.

Now as to the cause of the observed phenomena. This is one of the many cases where the facts once established it is easily shown that they are in accordance with theoretical considerations, but the deduction of the phenomena *a priori* from the theory seems never to have been made.

The bodily settlement of the ship is readily accounted for by the stream line theory. Suppose the ship as she advances to be surrounded by a thin, frictionless, unyielding sheet of ice at the surface, which travels with her and extends far enough in every direction to prevent any surface disturbances. We should then have perfect stream line motion past the immersed surface of the ship. For a small portion of the length, perhaps an eighth, at each end, the pressure of the water would be greater than if the ship were at rest, but for the bulk of the ship, perhaps the central three-quarters of the length, the pressure would be decreased, the net result being a strong downward pull on the ship.

The action is more readily grasped if we adopt the further device of supposing the ship at rest and the whole mass of water flowing past. The mutual reactions would be unchanged. As the stream approached the ship the normal velocity would be checked and the pressure increased. At a comparatively short distance abaft the bow, however, the velocity would return to the normal and amidships it would be decidedly above the normal (since the area for flow is lessened by the section of the ship), and the pressure correspondingly below the normal. (See papers by me on "Shipshaped Stream Forms" and "Stream Forms in Three Dimensions" read before the Institution of Naval Architects in 1894 and 1895.)

At each point the excess or defect of pressure would vary as the square of the speed, and hence the total downward pull in the imaginary case would vary as the square of the speed.

In the actual case the ship is free to settle in obedience to the downward pull and probably at low speeds the actual settlement in deep water is closely proportional to the square of the speed. The matter is soon complicated for the actual ship by the wave disturbance which she sets up in the water. The bow and the stern each sets up a series of waves of which the length, or distance between successive crests, increases with the speed. Figs. 1, 2, 3 and 4 show for the 20-ft. models a sudden change at a speed above 5 knots. Now at about 5 knots for a 20-ft. model there is a bow wave crest near the bow. The succeeding hollow is nearly amidships and the second crest is forward of the stern, holding up the quarter of the ship, as it were. As speed is increased, however, this crest rapidly moves astern, while the preceding hollow moves aft to the stern. The stern, no longer supported by the crest, drops into the hollow and the maximum change of trim makes its appearance. When speed is pushed still further the hollow in its turn moves aft and the ship rides on the back of her own wave. Speeds at which this occurs, however, are reached only by torpedo craft.

In Fig. 4 there is a secondary critical speed a little above four knots. The model referred to in Fig. 4 has a long parallel middle body and hence makes very strong waves. As the speed increases above four knots a bow wave hollow passes the stern, which drops into it. For most models at this speed the bow wave is not pronounced enough when it reaches the stern to notably affect the shape of the settlement curves. We often find, however, unfair places in the settlement curves between four and five knots, probably due to this cause. Fig. 3, for example, shows them.

The general question of increase of draft of ships under way in shoal water could be readily and accurately investigated by model experiments. An investigation of this nature, but directed more particularly toward the effect of shoal water upon resistance of ships, has been contemplated for some time at the Experimental Model Basin, but has been repeatedly postponed to a more convenient season on account of pressing current work. The changes of resistance and draft to be expected from a ship under way in a canal also need investigation.

Very respectfully, D. W. Taylor,
Naval Constructor, U. S. N.
Bureau of Construction and Repair, Navy Department,
Washington, D. C., Aug. 12, 1904.

The Cause and Prevention of So-Called Sewer Gas Explosions.

Sir: The frequent occurrence of sewer gas explosions, particularly those two that happened some time ago in 39th and So. Halsted Sts., Chicago, killing and injuring several persons, leads me to write you in regard to methods and means used in Europe for preventing such accidents.

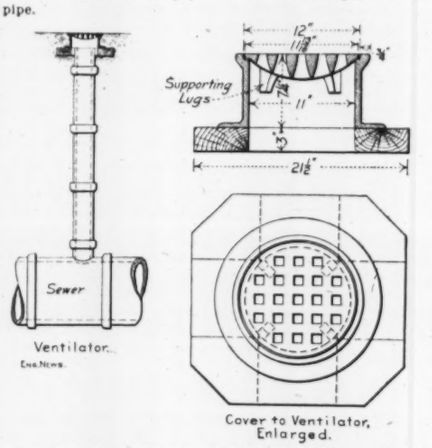
The general cause of the frequent sewer gas explosions in this country is insufficient ventilation. In most cities there is generally only one manhole for every 400 or 500 ft., and these manholes are very often covered with nearly air-tight covers, making the sewer conduit a good gas-chamber.

The accompanying drawings, taken from the writer's practice, are standard sizes for the sewers of Gothenburg (Sweden), designed by Professor Richert, in Stockholm, some 15 years ago. The conduits must be easily accessible for inspection and repairs; thus they are laid in straight lines between manholes and ventilators, the distance between the latter being about 100 ft. The manhole covers are perforated. Naturally the lighter and most dangerous sewer gases seek their way up through these holes. It is very seldom that the ventilators or manholes give a bad odor, and, if so, they tell the presence of precipitated matter in the sewer conduit which has to be removed.

In the construction of the ventilators it is to be noted that the upper end of the vertical pipe is free, so that it does not take any load which might cause the breakage of the sewer pipe.

The above described method is the cheapest and easiest adaptable in this country, one of its features being that it does not interfere with the prevailing laws and ordinances.

A newer and more expensive and troublesome method is the placing of vertical ventilating pipes on each or every second house, connected with the sewer by a horizontal pipe. The city pays for the horizontal part of the pipe, and the house-owner pays for the vertical part of the pipe.



Sewer Ventilating Shaft with Perforated Cover Flush with the Street Level.

Another method is the attaching of electric fans to the ventilating pipes, thus giving a greater efficiency to only a few ventilators. The outlet of these ventilators ought to be about 3 ft. above the house roofs.

Respectfully yours, C. H. Liedbeck, C. E.
4748 Calumet Ave., Chicago, Ill., Aug. 9, 1904.

(The drawings sent included details of a perforated manhole cover and of a ventilating shaft having a perforated iron cover flush with the street surface. Ventilated manhole covers are so common in this country that we have not reproduced the details of one sent with this letter, particularly as it is similar in most respects to the cover of the ventilator shaft shown herewith, even to the wood support for the iron ring. A design for a ventilator shaft of the same general character as the one here shown, but with different details, is figured opposite p. 134 of Staley's "Separate System of Sewerage" (New York, 1899,) only it is called a fresh-air inlet instead of a ventilating shaft. In the design here illustrated the wood support to the iron ring seems objectionable, both as regards first cost and probable early decay. That, however, is a minor matter, easily remedied by omitting it. The serious question is whether these ventilators, at 100-ft. intervals, would be of enough service to warrant their cost? Explosions aside, probably not. The majority of explosions in sewers are probably due to illuminating gas from leaky gas mains. In good sewer design manholes are placed at intervals of 500 ft. or less and in many instances they have perforated covers. Add four such ventilating shafts as are here pictured and what further safety has been secured? We leave the question to our readers. The alternative of ventilating sewers through the drain and soil pipes of houses is a mooted question, but it is on the side of economy, since all that is necessary is to omit the main or running trap on the house sewer. Such a proposition would horrify many British sanitarians, for in England most municipal health authorities, not content with a running trap, insist on a disconnecting trap, so there will be an open break between the street and house sewer.—Ed.)

Notes and Queries.

In our issue of Sept. 8, p. 211, two views were shown of Sullivan electric coal-cutting machines, Fig. 1 being a "long-wall machine," and Fig. 2 being a "room and pillar machine." The long-wall machine was not described, although illustrated, which may have led to some confusion. The room and pillar machine makes its cut upon the same principle as the long-wall machine, that is, the entire face is undercut in one operation, but the cutter bar is rigidly fixed and is not swung out as shown in the cut of the long-wall machine. The latter machine, on the other hand, does not have the long detachable frame or pan which is characteristic of the room and pillar cutter, but, when starting the cut, the machine with cutter bar in line is placed parallel to the face of the coal, and the bar is then swung under the coal, and the machine traverses the face with the bar in right angle position.

THE DESIGNS FOR THE MANHATTAN BRIDGE over the East River submitted to the New York Art Commission in June last by Commissioner Geo. E. Best were approved by the Commission at a meeting on Sept. 15 by a vote of 7 to 1. The designs were published in our issue of July 7. Bids for the superstructure are soon to be advertised for.

THE IMPROVEMENT IN THE WATER SUPPLY OF Chicago, noted editorially in our issue of Sept. 1, was partly due to meteorological conditions, according to the bulletin of the Chicago Health Department for Sept. 10. That is to say, the rainfall of 0.91 in. on July 31 did not have the usual bad effect upon the water supply, because a long dry spell preceded the rain. The ground, therefore, absorbed a large part of the precipitation and the deposits in the sewers were not flushed out as is usual at times of heavy rainfalls. Commenting on our remarks as to the diversion of sewage from the lake, the bulletin states that

there has been no improvement in this direction since 1898, when the flow of the 12th St. and the 22d St. sewers was diverted into the South Branch of the river. The 39th St. intercepting sewer system, although practically completed, will not be in operation much before the middle of October, whilst work on the North Shore system is still tied up by litigation.

CONTRACTS FOR THE BARGE CANAL across New York State will soon be advertised. Plans and specifications for six contracts are reported to be nearly ready for letting. These six contracts embrace the most difficult and uncertain work to be done on the canal, and will be advertised first to determine whether the appropriation of $101,000,000 will be ample or not for building the canal. Contracts Nos. 1 and 3 will cover a section of the Champlain Canal from Northumberland to Fort Edward. Contract No. 2 will cover locks Nos. 2 and 3 on the Erie Canal and a part of the canal from the Hudson River extending a mile west. Contract No. 4 covers five miles of canal at the east end of Oneida Lake. The excavation will be a fine sand that will probably be handled with hydraulic dredges. Contract No. 5 will cover a section through the Montezuma marshes. Contract No. 6 will cover about four miles of new canal between Rochester and South Greece. Contracts Nos. 1 to 3 will be advertised first. Contracts Nos. 1 to 6 cover about all the Barge Canal work that will probably be done for a year or more.

THE RAILWAYS OF INDIA aggregated 26,956 miles at the end of 1903, and of this total 1,345 miles were in Burmah. There were 14,477 miles of the standard gage of 5 ft. 6 ins.; 11,421 miles of meter gage; 796 miles of 30 ins. gage, and 262 miles of 24 ins. gage. The total length of railways open on April 30, 1904, was 27,140 miles, with 3,122 miles under construction or authorized. During the year 99 stations were fitted with interlocking plants, and 109 stations were fitted with automatic instruments for signaling trains between stations. There are 2,390 engines, 9,732 passenger cars and 2,008 freight cars fitted with automatic brakes, while the total equipment is as follows: locomotives, 5,429; cars in passenger service, 19,555; cars on freight service, 103,297. The passengers numbered 210,231,000, with an average haul of 101¾ miles per first-class passenger, and 41 miles per fourth-class passenger. The freight carried aggregated 43,852,000 tons. The operating expenses represented 47.52% of the gross earnings: maintenance of way, works and stations, 10.80%; locomotive expenses, 16.99%; car expenses, 1.24%; traffic expenses, 8.11%; general charges, 4.60%. There are 402,249 employees; only 6,022 are Europeans, the others including 8,661 Eurasians and 387,566 natives. The accidents resulted in 1,143 persons being killed and 1,142 injured.